Future scenarios for Monongalia County's solid waste management system

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ABBREVIATIONS

CH_4	methane
CO_2	carbon dioxide
CO_2e	carbon dioxide equivalent
GHG	greenhouse gas
GWP	global warming potential
MCSWA	Monongalia County Solid Waste Authority
MRF	materials recovery facility
MSW	municipal solid waste
MT	metric ton
MTS	Mountaineer Transfer Station
PEF	Processed engineered fuel
RDF	refuse-derived fuel
USEPA	U.S. Environmental Protection Agency
WVU	West Virginia University

1. INTRODUCTION

The Monongalia County Solid Waste Authority (MCSWA) seeks innovative solutions to address solid waste issues facing the county now and for decades into the future. Recent projects have focused on understanding the potential of gasification to reduce the amount of municipal solid waste (MSW) sent to landfills (Hansen et al., 2016). This report broadens MCSWA's discussion to consider increased recycling and composting in addition to gasification.

Investigating future options for the county's solid waste management system fits within MCSWA's responsibilities, which include, among other things, local and/or regional solid waste planning, coordinating public education and awareness, and solid waste and litter control project coordination/management. MCSWA seeks to lead the improvement of solid waste services for the benefit of county residents and, consistent with its recent litter and solid waste control plan, has committed to educating residents about solid waste disposal options through reuse, recycling, or, as a last resort, landfilling and to protect public and environmental health, safety, and welfare (MCSWA, 2016).

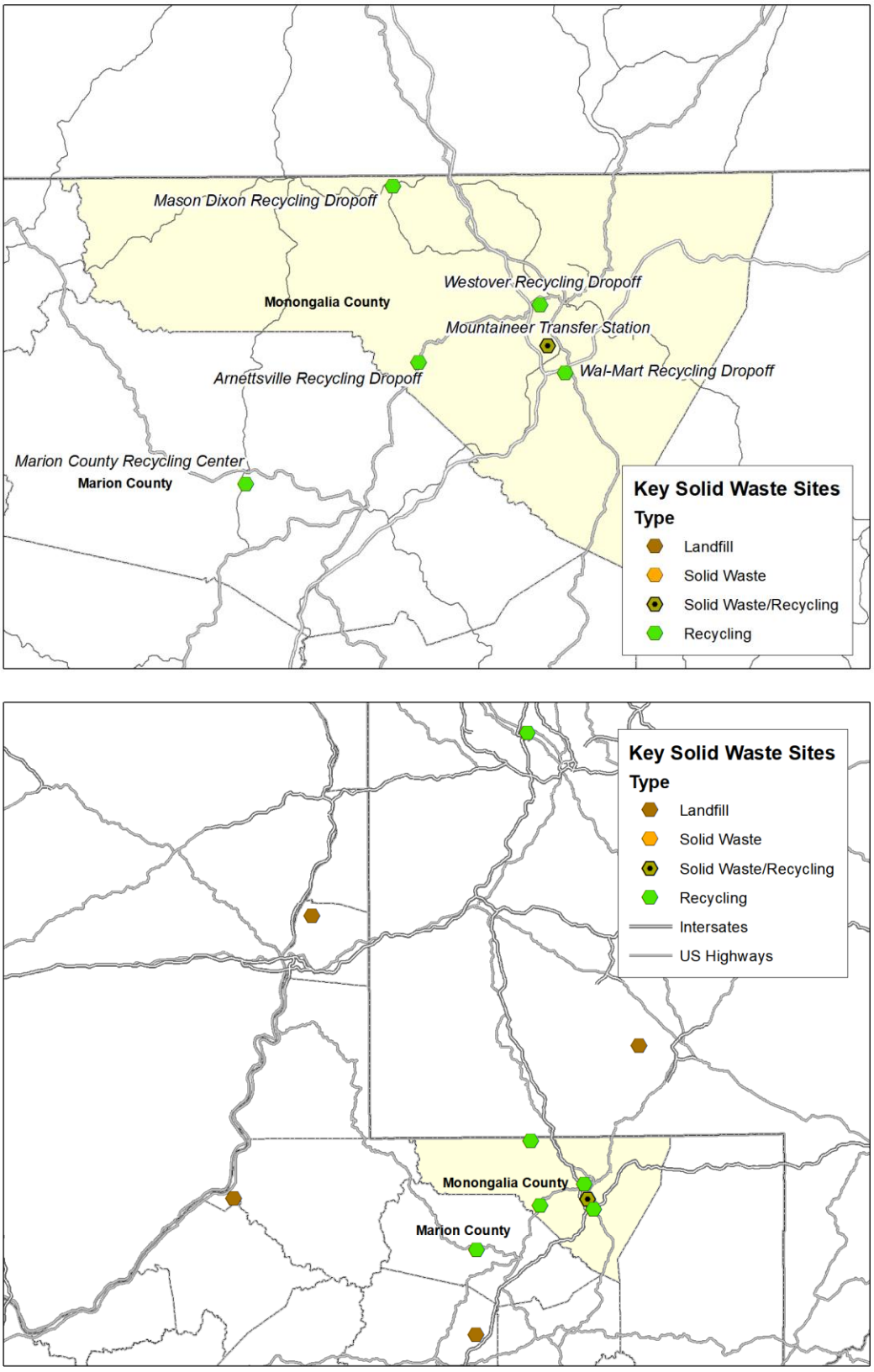
Monongalia County has a growing population, and as described in more detail in this report, the county's MSW and recycling system is complex. It is managed differently among its five municipalities,[1] West Virginia University (WVU), and unincorporated parts of the county. Most MSW and recyclables are trucked to the Mountaineer Transfer Station (MTS) in the Morgantown Industrial Park (See Figure 1). From there, most waste is shipped to Short Creek Landfill in Ohio County, West Virginia, and recycling is shipped to Greenstar Recycling, a materials recovery facility (MRF) near Pittsburgh. However, some of the county's waste is shipped to other landfills, and some recyclables are collected by and transported to the Marion County Solid Waste Authority, in nearby White Hall, West Virginia.

Five private haulers serve different parts of the county. WVU and the municipalities of Star City, Westover, and Granville provide curbside service and haul their own MSW. Morgantown, Star City, and Westover have instituted single-stream recycling with weekly, curbside pickups. WVU has an extensive, campus-wide, single-stream recycling program that has expanded rapidly in the last three years. The only choice for recycling for residents outside of these areas is to drop off their recyclables at one of four drop-off locations: the Mason Dixon and Arnettsville locations in the western part of the county or the Wal-Mart and Westover locations, which are only open at limited times.

This system is not optimal. As detailed below, recycling rates in Monongalia County are low by national standards. Local governments are not coordinating efforts to generate efficiencies. In addition, residents not served by curbside recycling have few drop-off locations, and these sites depend on volunteer labor.

[1] This report specifically considers the four municipalities in the greater Morgantown area (Morgantown, Star City, Granville, and Westover) but does not specifically consider Blacksville.

Figure 1: Key features of Monongalia County's solid waste management system



In this report, we track Monongalia County's MSW and recyclables from hauling, to the MTS and recycling drop-off centers, and to landfills. We then create three scenarios for comparison:

1. **the Base Case Scenario,** which describes current MSW and recycling flows,
2. **the Increased Recycling and Composting Scenario,** which increases recycling and adds composting, and
3. **the Gasification Scenario,** which diverts MSW to a gasification facility.

The goals of this report are:

- to clarify the amount and destination of MSW and recyclables across the county,
- to consider two broad options—increased recycling and composting, and gasification—for diverting a portion of the county's MSW from landfills, and
- to estimate the economic and environmental costs and benefits associated with these options.

Solid waste authorities are required to update their comprehensive litter and solid waste control plans every five years. In Monongalia County, MCSWA submitted its most recent plan in 2016 (MCSWA, 2016). The required contents of these plans are specified in state rules,[2] and these plans are subject to review and approval by the West Virginia Solid Waste Management Board. This report is not a formal update of the 2016 plan; however, much of the information presented in this report will be useful as a source for updating that plan in the future.

[2] W.Va. Code of State Rules §54-3.

2. MONONGALIA COUNTY'S CURRENT SOLID WASTE MANAGEMENT SYSTEM: THE BASE CASE SCENARIO

In this chapter, we create a Base Case Scenario that models Monongalia County's current solid waste management system. Based on this analysis, we draw conclusions about the current system, and we also set the stage for comparison to the two potential future scenarios presented in Chapters 4 and 5.

In the current system, the key entities include customers, WVU, haulers, independent recycling programs, the MTS, landfills, and Greenstar Recycling.[3] These entities encompass all stops along the pathway taken by MSW and recyclables from customers to the final destinations considered in this report: landfills, independent recycling programs, or Greenstar Recycling. They also encompass the points at which money is exchanged and environmental impacts occur.

2.1 Municipal solid waste

Figure 2 illustrates our best estimate of the recent annual flows of MSW and recyclables in Monongalia County. These data are sourced largely from the MTS's 2014 Annual Report (Bayes, 2014), which, unlike reports for other years, included a detailed, customer-by-customer breakdown. Data from other entities are from 2016 and were compiled from original research, from other reports such as landfill annual reports, or by estimation.

Most of the MSW and recyclables included in our analysis originates from households rather than businesses. One large entry, labeled "Other Commercial," encompasses the dumpster tonnages reported by Republic, which include businesses as well as residences with dumpsters such as apartment buildings. No special waste, such as construction and demolition waste, is included in this analysis. We have endeavored to gather data that is as current as possible, but due to its reliability and completeness, we combined and reconciled data from 2014 and more recent years.

In the Base Case, a total of approximately 65,000 tons of MSW and recyclables are generated in Monongalia County. Approximately 62,000 tons (95 percent) are taken to the MTS or directly to landfills, while only approximately 3,000 tons (5 percent) are recycled.

Five private haulers collect waste in Monongalia County:

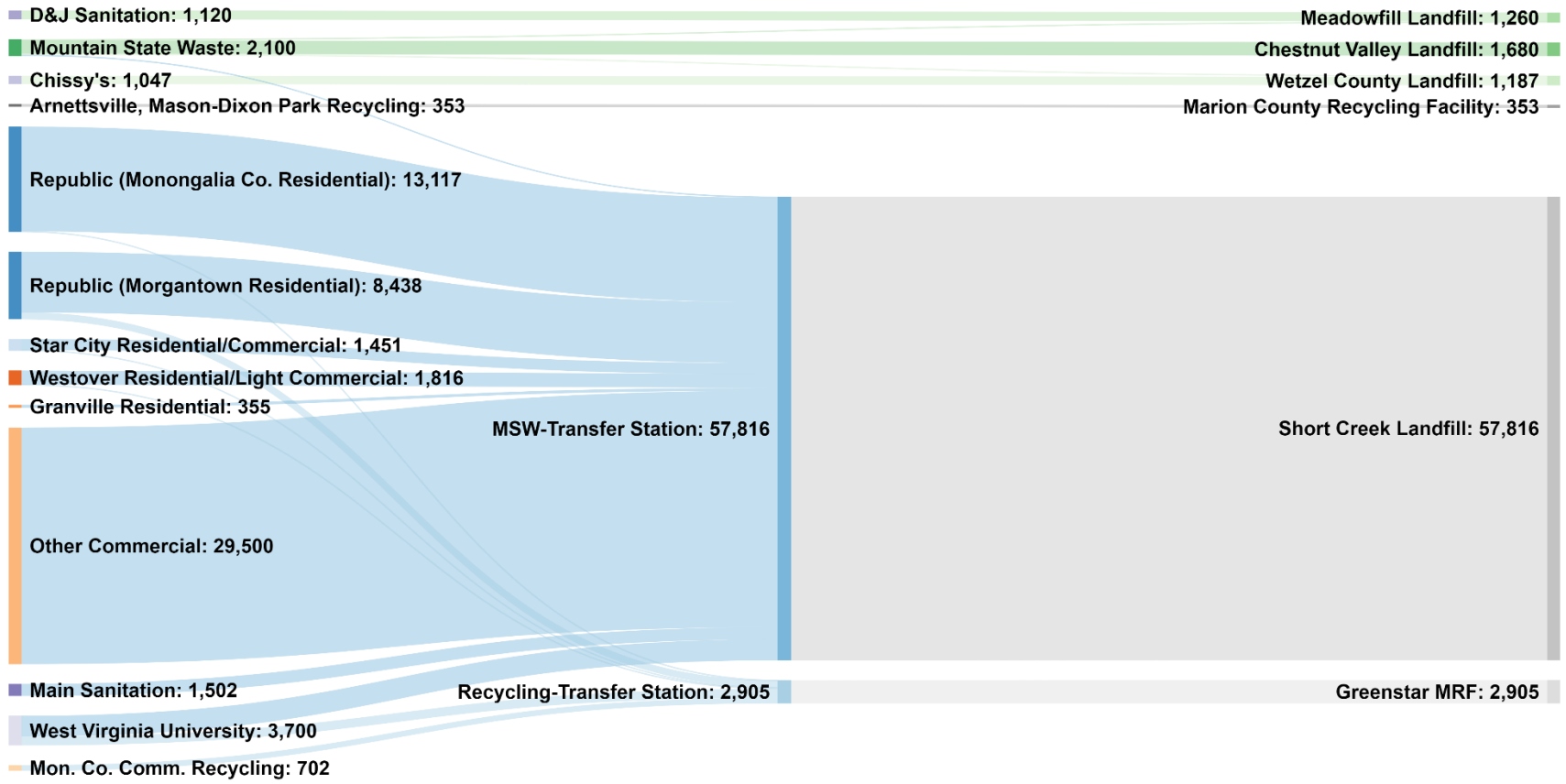
- Republic Services,
- Mountain State Waste,
- Main Sanitation,
- D&J Sanitation, and
- Chissy's.

As illustrated in Figure 2, three of these haulers transport their waste directly to landfills, bypassing the MTS: D&J Sanitation to Meadowfill Landfill, Chissy's to Wetzel County Landfill, and Mountain State Waste to Wetzel County, Meadowfill, and Chestnut Valley landfills. Mountain State Waste also hauls a portion of its MSW to the MTS.

However, Republic Services, which has the largest customer base in the county, trucks its waste to the MTS en route to Short Creek Landfill. Both the MTS and Short Creek Landfill are owned and operated by Republic Services. Republic is the second-largest solid waste firm in North America (Waste360, 2016).

[3] Understanding Monongalia County's current solid waste management system required a great deal of research and the compilation of data and information from disparate sources. The picture of the solid waste system that we have developed here necessarily utilizes some estimates, but it is nonetheless very thorough. We have gathered enough information to estimate changes from the Base Case to alternative future scenarios.

Figure 2: Flows of municipal solid waste and recyclables in the Base Case Scenario (tons per year)



Source: Calculated in this report.

2.2 Recycling

Recycling follows a similar trajectory. Nearly all of Monongalia County's recycling passes through the MTS on its way to Greenstar Recycling. Greenstar Recycling is owned and operated by Waste Management, the largest solid waste firm in North America (Waste360, 2016).

Only an estimated 5 percent of Monongalia County's solid waste stream is recycled. That recycling is captured by a number of entities:

- Republic Services;
- the municipalities of Morgantown, Westover, and Star City;
- the Monongalia County Commission;
- WVU; and
- the Marion County Recycling Center, which operates drop-off sites in the western part of Monongalia County.

With the exception of the recycling gathered by the Marion County Recycling Center, all of this material (approximately 2,900 tons per year) ends up at the MTS before being trucked to Greenstar Recycling. The material collected by the Marion County Recycling Center is sorted, bundled, and marketed by them.

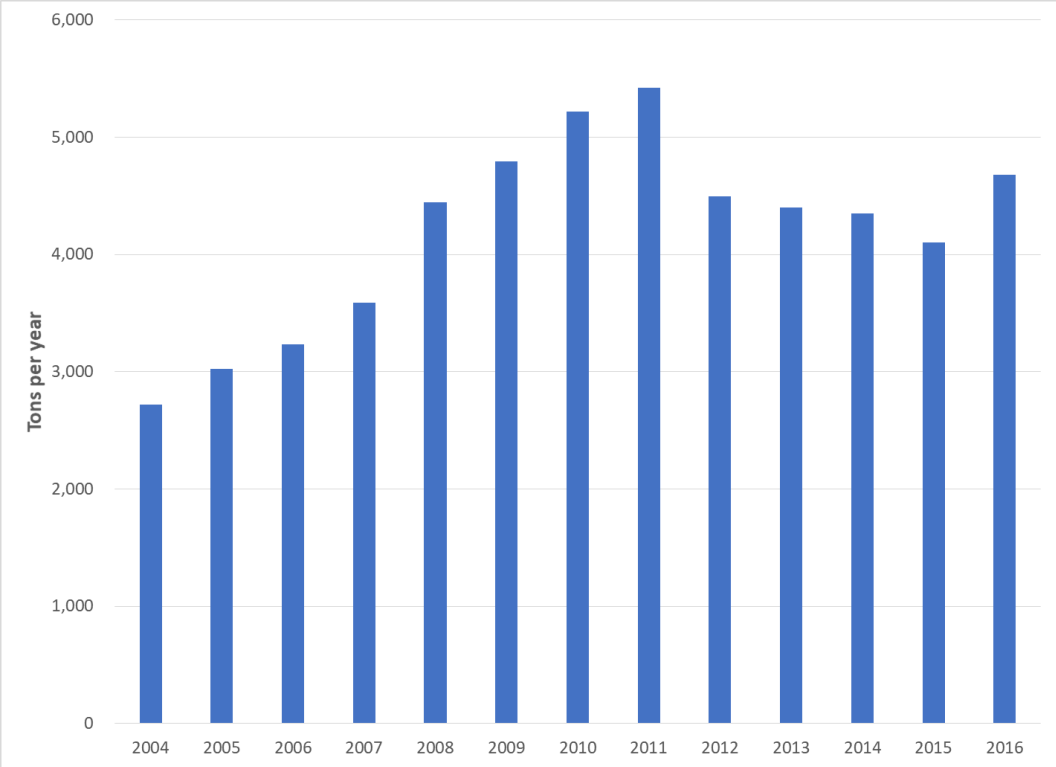
Recycling in Monongalia County has not always been handled by this disparate set of haulers and drop-off locations. Prior to 2013, the MCSWA operated a successful source-separated drop-off recycling facility, with associated drop-off locations, that collected many different types of recyclables from county residents. As shown in Figure 3, the amount of recycling collected within Monongalia County gradually increased from 2004 through 2011 due to this successful program.

Things changed, however, when this facility closed, even though many entities have stepped forward since then to collect recyclables. Morgantown, Star City, and Westover have instituted single-stream recycling with weekly, curbside pickups. WVU has an extensive, campus-wide, single-stream recycling program that has expanded rapidly in the last three years. But the only choice for recycling for residents outside of these areas is to take recyclables to one of four drop-off locations: the Mason Dixon and Arnettsville locations in the western part of the county or the Wal-Mart and Westover locations, which are only open at limited times.

As illustrated in Figure 3, recycling in Monongalia County has not reached 5,000 tons since its peak years in 2010 and 2011. One possible reason for this drop off in recycling is the loss of MCSWA's recycling facility and drop-off sites that existed in the county prior to 2013. Even though three municipalities have instituted single-stream recycling, these recycling programs do not serve the large number of people who live outside of these municipalities who previously took advantage of MCSWA's program.

Recycling rates in Monongalia County are quite low. Only an estimated 5 percent of the county's total waste is recycled. Recycling rates are estimated to be 10 percent in Morgantown, 7 percent in Star City, and 4 percent in Westover. For comparison, an estimated 26 percent of MSW is recycled across the country (USEPA, 2016). Clearly, there is significant room for improvement in Monongalia County and within the municipalities that offer single-stream recycling.

Figure 3: Recycling in Monongalia County (tons, 2004-2016)



Sources: Civil Design Solutions (2014, 2015, 2016, and 2017), MCSWA (2015), Knabenshue (2017), WVU Office of Sustainability (2018), Golden (2017), Bloom (2017). Note: These data are incomplete. Mountaineer Transfer Station data from 2004 to 2012 were unavailable, meaning that values in these years are underestimated.

2.3 The solid waste economy

Just like the actual materials collected, dollars flow through the solid waste management system, and just like solid waste, these dollars first originate from customers. They are passed on to haulers (or municipalities that offer hauling services such as Westover, Star City, and Granville), which utilize those dollars to pay personnel and transportation costs—which we are unable to quantify here—as well as tipping fees paid to landfills or to the MTS.

Tipping fees are particularly important to this discussion because they are the primary way by which dollars are propagated through the system and, in the case of the MTS, landfills, and the hypothetical facilities discussed in the future scenarios, they are the central element upon which the economics of a facility are determined. While the MTS and landfills have access to individual, drive-up customers, most waste and recyclables, and most associated tipping fees, will come from solid waste haulers.

For MSW, customers generally pay haulers, and haulers generally pay landfills or the MTS. The flow of recycling dollars is more complex. For the municipalities that offer single-stream recycling, customers pay haulers for both recycling and MSW as part of their periodic bills; haulers take the recyclables to the MTS and pay a tipping fee.

The Monongalia County Commission has entered into a private arrangement with the MTS regarding its recycling program. The Commission operates two drop-off locations: (1) a business-hours single-stream location in Westover, and (2) a manned weekly single-stream drop-off event at the 4-H Camp Road Wal-Mart

most Saturday mornings. The County Commission pays $235 per dumpster haul for this service. In 2016, the County Commission paid $57,000 for this program (Bloom, 2017).

These dollars are, effectively, a subsidy to haulers, whose tonnages and tipping fees are decreased accordingly for each ton of recycling handled by the County Commission's program. An estimated 702 tons per year were handled by the County Commission; if these recyclables were collected by haulers and trucked to the MTS, and if the $62.50 MSW tipping fee were applied, this represents an approximately $44,000 subsidy to haulers—in addition to reduced transportation costs. One unique aspect of this program is that it relies largely on volunteer labor; therefore, it may be difficult to sustain the program into the future, particularly if the program were expanded to serve additional county residents.

The Marion County Solid Waste Authority operates two source-separated recycling drop-off locations in the western part of Monongalia County. This program involves no payments to the Marion County Solid Waste Authority from any entity within Monongalia County, but it also effectively acts as a subsidy to haulers by reducing MSW and the associated tipping fees and transportation costs that must be paid by haulers. An estimated 353 tons per year were handled by the Marion County Solid Waste Authority; if these recyclables were collected by haulers and trucked to the MTS, and if the $62.50 MSW tipping fee were applied, this represents an approximately $22,000 subsidy to haulers—in addition to reduced transportation costs

Most recycling produced in Monongalia County passes through the MTS on its way to Greenstar Recycling. Greenstar Recycling accepts a disposal fee, but it also pays a rebate based on the composition of the waste stream and market conditions per commodity.[4] MTS incurs other costs, such as transportation costs.

2.4 Environmental impacts

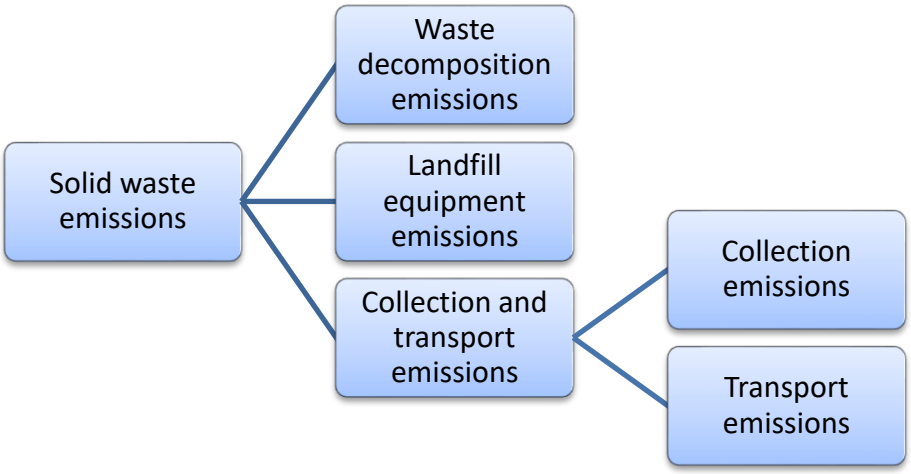
Rather than calculating the environmental impacts separately for the Base Case Scenario and the future scenarios (the Increased Recycling and Composting Scenario and the Gasification Scenario), impacts are estimated for the changes in flows between the scenarios. For that reason, no separate estimates of emissions are provided in this chapter for the Base Case Scenario.

In general, however, changes to the solid waste management system will impact greenhouse gas (GHG) emissions associated with: (1) collecting MSW from the community and transporting it to the landfill, (2) landfill equipment, and (3) waste decomposition at the landfill (See Figure 4).

These emissions, plus others specific to the future scenarios, are calculated in Chapters 4 and 5.

[4] At least twice a year, a sample volume of recyclable material from the MTS is sorted and categorized by Greenstar Recycling. That audit allocates the material into proportions—percentage of #1 plastic, percentage of cardboard, etc.—and also defines a percentage of the total that is not recyclable and must be disposed of in a landfill. The latter number, landfill waste, is used to calculate a disposal fee (to be charged back to the MTS) per ton of material delivered, and the remaining proportions are used, in conjunction with recent commodity prices to determine a rebate value per load, some portion of which is paid back to the MTS. Typically, that rebate is split: Greenstar Recycling likely pays out 80 percent of the calculated rebate value to the MTS. The final dollar value is then calculated as rebate dollars minus disposal fees. (Moser, 2017)

Figure 4: Solid waste management greenhouse gas emissions components



2.5 Key observations

This compilation of data and estimates in the Base Case Scenario allows for a number of key observations.

- In the Base Case, a total of approximately 65,000 tons of MSW and recyclables are generated in Monongalia County.
- Approximately 62,000 tons (95 percent) are taken to the MTS or directly to landfills, while only approximately 3,000 tons (5 percent) are recycled.
- Compared with the national average of 26 percent, the recycling rate in Monongalia County is low.
- Recycling in Monongalia County has not reached 5,000 tons since its peak years in 2010 and 2011.
- Recycling rates for the municipal, single-stream, curbside recycling operations are also lower than the national average. Recycling rates are estimated to be 10 percent in Morgantown, 7 percent in Star City, and 4 percent in Westover.
- The Monongalia County Commission's recycling program, while successfully diverting approximately 702 tons from landfills, relies largely on volunteer labor; therefore, it may be difficult to sustain the program into the future.
- The recyclables diverted by the Monongalia County Commission's recycling program represent a subsidy of approximately $44,000 to haulers.
- The recyclables diverted by the Marion County Solid Waste Authority's recycling program represent a subsidy of approximately $22,000 to haulers.

3. OPTIONS FOR IMPROVING MONONGALIA COUNTY'S SOLID WASTE MANAGEMENT SYSTEM

As documented in Section 2.1, only approximately 5 percent of Monongalia County's solid waste is diverted from landfills to recycling. To help inform options for improving the county's solid waste management system, we reviewed several solid waste management plans, with an eye toward established, achievable strategies for diverting waste from landfills.

A central component of many solid waste plans in the United States is to plan for reducing the volumes of waste destined for landfills. The means for achieving this goal vary and depend on many factors, including the demographics of the community, the resources already in place, and the resources (both in terms of existing infrastructure as well as finances) available for utilization.

Solid waste plans are available across the country; however, the plans from Austin (City of Austin, 2011) and Central Ohio (GT Environmental, 2011) were chosen for a detailed review due to their clearly stated, ambitious goals, which are in line with the stated interests of the MCSWA for the Increased Recycling and Composting Scenario. In terms of population and service area, these regions are quite different from Monongalia County, but our research suggests that several of the methods employed in these areas are potentially feasible in Monongalia County.

The third plan reviewed in detail was written for Montgomery County, home to Virginia Tech University (Olver, Inc. and Joyce Engineering, Inc., 2010). This plan commits to similar goals as the other two plans; however, its population and service areas are more similar to Monongalia County.

On the whole, these plans are very complete and, while their individual goals vary, they each represent steps along the road to dramatic and ambitious changes to solid waste management systems. Austin aspires to become a zero-waste community by 2040, which requires diverting 90 percent of solid waste from landfills. While Montgomery County maintains more modest goals, those goals are in line with their current resources and capacity. Central Ohio falls somewhere in between; the region already boasts successful composting and recycling programs and, for the time being, seeks to improve participation and efficiency of these programs rather than introducing new efforts. Despite their difference, all three plans seek to reduce the volume of solid waste going to landfills while improving service to customers.

Our research found three key strategies for diverting waste from landfills:

1. increasing recycling,
2. implementing a new composting program, and
3. initiating an auditing service for large customers.

Previous research performed by Downstream Strategies on behalf of the MCSWA identified a fourth potential strategy: diverting waste to a gasification facility (Hansen et al., 2016).

3.1 Increasing recycling

Nationally, a large portion of the solid waste stream—approximately 50 percent—is comprised of recyclable material (USEPA, 2016) and because of this, increasing recycling is an obvious opportunity to substantially reduce the flow of MSW to landfills.

An additional benefit of increasing recycling is to reduce GHG emissions. Landfills generate almost 2 percent of total U.S. GHG emissions (USEPA, 2017), and recycling reduces these emissions (USEPA, 2016).

A third benefit in Monongalia County is to extend the life of the MTS under its current permit, which limits the MTS's monthly tonnage of MSW. Recycling does not count toward this limit (Flenner, 2017). As

Monongalia County continues to grow, increased recycling will allow the MTS to continue to operate at its currently permitted level.

As noted previously, Monongalia County's recycling rate is approximately 5 percent, as compared with the national average of 26 percent (USEPA, 2016). USEPA notes that 38 percent of landfilled waste is either plastics (19 percent), paper and paperboard (14 percent), or glass (5 percent), much of which is recyclable; therefore, even the 26 percent national average can be improved. Monongalia County clearly has significant room for improvement.

One method for increasing recycling rates would be to improve participation in the current curbside, single-stream recycling programs in Morgantown, Star City, and Westover. A second method would be to expand curbside, single-stream recycling to additional households. A third would be to increase the number of drop-off recycling locations and/or to increase the number of days and hours that current drop-off locations are open.

3.2 Implementing a new composting program

A second less common, higher risk (relative to recycling), but highly effective way to divert MSW from landfills is to compost organics. This most often takes the form of curbside organic collection, which trucks materials to a compost facility. The finished product, compost, is a potentially valuable commodity, though markets are unpredictable. USEPA estimates that nearly 30 percent of the material entering landfills is food waste or yard trimmings, all of which is compostable. Another 22 percent is made up of wood, paper, and cardboard, which can also be composted. (USEPA, 2016)

Composting these materials has several benefits. First, aerobic decomposition via the compost process releases fewer GHGs in the form of carbon dioxide (CO_2), as compared with the methane (CH_4) produced via anaerobic decomposition in a landfill. Composting also diverts organic matter from landfills so that the material can be put to productive use in yards and gardens.

Nationally, curbside compost programs are still an emerging activity, but compost is increasingly seen as a viable option for the diversion of organic materials from landfills. Both Washington, D.C. (Fenston, 2017) and New York City (Rosengren, 2017) have begun to develop compost programs, for example. Central Ohio boasts a very large operation (GT Environmental, 2011). Austin, too, has recently expanded its composting program from an 11,000-home pilot program to the entire city (Rodas, 2017; Cantú, 2017). Curbside compost programs are not without their downsides and challenges (Mesch, 2017), but good planning and sound implementation of these programs has paid dividends for a variety of participants, nationally and internationally (Karidis, 2017; Santin, 2017).

3.3 Diverting waste to a gasification facility

Gasification technologies have been discussed extensively in Downstream Strategies' previous report submitted to the MCSWA (Hansen et al., 2016). Gasification of solid waste is an emerging technology that utilizes the energy stored within solid waste and, under low- or no-oxygen conditions, converts the solid waste into "syngas." Most producers of gasification technology use the syngas to either generate electricity or as an input into liquid fuels production, but the gas can be used to create many of the chemicals that now rely upon natural gas as a feedstock. Gasification of solid waste is much more challenging than gasification of more uniform feedstocks, such as wood, coal, or tires. It requires that the MSW be prepared for use in a gasifier in order to ensure production of a consistently usable syngas.

No commercially operating gasification plants fueled by MSW have been identified in the United States or Canada, with the most notable example being a facility in Ontario, Canada that is now out of business

(Hansen et al., 2016). Still, this emerging technology is potentially attractive because it can divert a large amount of waste from landfills and turn that waste into electricity or another valuable commodity.

Our primary model for a hypothetical gasification facility is the Aries Clean Energy (formerly PHG Energy) facility in Lebanon, Tennessee. This facility gasifies approximately 32 tons of commercial wood waste, 4 tons of sewage sludge, and 4 tons of tires per day, which is used to drive three generators to produce electricity for an adjacent sewage treatment plant.

This facility does not use MSW as a fuel at this time; however, representatives of Aries Clean Energy have noted that gasification of MSW is "the [most important] nut to crack" in the industry, as it represents the most pressing material disposal problem in the United States. Aries Clean Energy is currently partnering with Waste Away, a manufacturer of refuse-derived fuel (RDF), as it tests and refines its gasifier technology with RDF as the primary feedstock (Snyder, 2017). RDF is a pelletized fuel produced by sorting, separating, and drying solid waste.

At present, Entsorga WV is building a facility in Berkeley County, West Virginia, that will utilize unsorted municipal solid waste as a feedstock to produce a Processed Engineered Fuel (PEF). Entsorga's PEF has been recognized by the US EPA as a Non Hazardous Secondary Material, meaning that the PEF produced with Entsorga's process is a valuable commodity with a high calorific value that contains contaminants comparable to or lower than found in fossil fuels traditionally utilized by industrial consumers. Operation at the plant is expected to begin in early 2018. The key difference between fuels termed "RDF" and those termed "PEF" or solid refuse fuel (SRF), is that the former is manufactured from non-specified waste, while the latter is manufactured only from non-hazardous waste (ERFO, 2013). The manufacture of waste derived alternative fuels has an interesting effect on the waste stream: many recyclables (metals, glass, and other valuable materials such as cardboard) are sorted out prior to creation of the final product, potentially resulting in an increase in total recycling without additional effort from customers. The Entsorga project also utilizes an aerobic digestion process, which is designed to naturally reduce water content and partially digest organic matter, such as food waste, within the waste stream prior to the final manufacture of PEF. This, like composting, results in a net reduction of GHG as aerobic digestion produces CO_2 instead of the CH_4 emissions associated with the anaerobic decomposition of those same materials within a landfill. (Carollo, 2017)

To model a gasification plant and associated PEF plant, we utilized data from Aries Clean Energy and from Entsorga WV.

Figure 5: The future site of the Entsorga WV plant in Berkeley County, West Virginia

Source: Entsorga WV (2017).

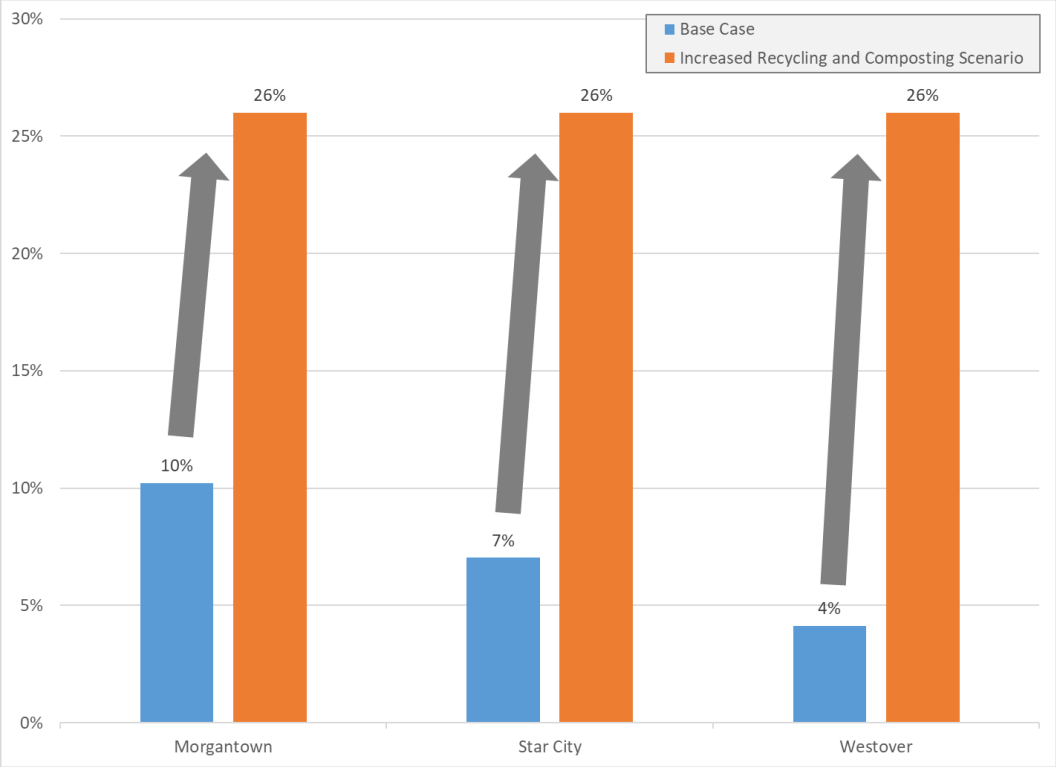
3.4 Two potential future scenarios for Monongalia County

Based on our analysis of Monongalia County's current solid waste management system (Chapter 2) and options for improving this system (Sections 3.1, 3.2, and 3.3), we identify two potential future scenarios for Monongalia County. The first, the Increased Recycling and Composting Scenario, contemplates an increase in recycling and the development of a new composting program; this scenario is described in Chapter 4. The second, the Gasification Scenario, contemplates the construction of gasification and PEF facilities and is described in Chapter 5.

4. THE INCREASED RECYCLING AND COMPOSTING SCENARIO

In the Increased Recycling and Composting Scenario, recycling rates in Morgantown, Star City, and Westover—the three municipalities with single-stream recycling—increase to the national average of 26 percent (See Figure 6). The scenario also includes increases in recycling for residents who live outside of these municipalities by doubling the total tonnage of recyclables captured by both the Monongalia County Commission and the Marion County Solid Waste Authority drop-off locations.

Figure 6: Municipal recycling rates in the Base Case and the Increased Recycling and Composting scenarios



Additionally, the Increased Recycling and Composting Scenario includes a new curbside compost program that receives organic waste from Morgantown residents and from WVU. For Morgantown residents, diversion to this new compost program is based on an assumption that 5 percent of Morgantown's customers would participate and that these customers would provide all of their compostable material for pickup. This totals approximately 118 tons of organic materials per year. WVU also generates a large amount of organic waste; in this scenario, an estimated 153 tons of WVU's organic waste are diverted to the new compost program based on a waste audit of WVU dining halls (Knabenshue, 2017).

4.1 Changes in flows

Table 1 summarizes the changes in flows in the Increased Recycling and Composting Scenario, as compared with the Base Case Scenario. These changes are also illustrated in Figure 7. Figure 8 compares the Base Case with the Increased Recycling and Composting Scenario and the Gasification Scenario.

The Increased Recycling and Composting Scenario would reduce the amount of MSW sent to the MTS, and ultimately the Short Creek Landfill, by approximately 3,000 tons per year. A very small amount of MSW would also be diverted from the Chestnut Valley, Meadowfill, and Wetzel County landfills.

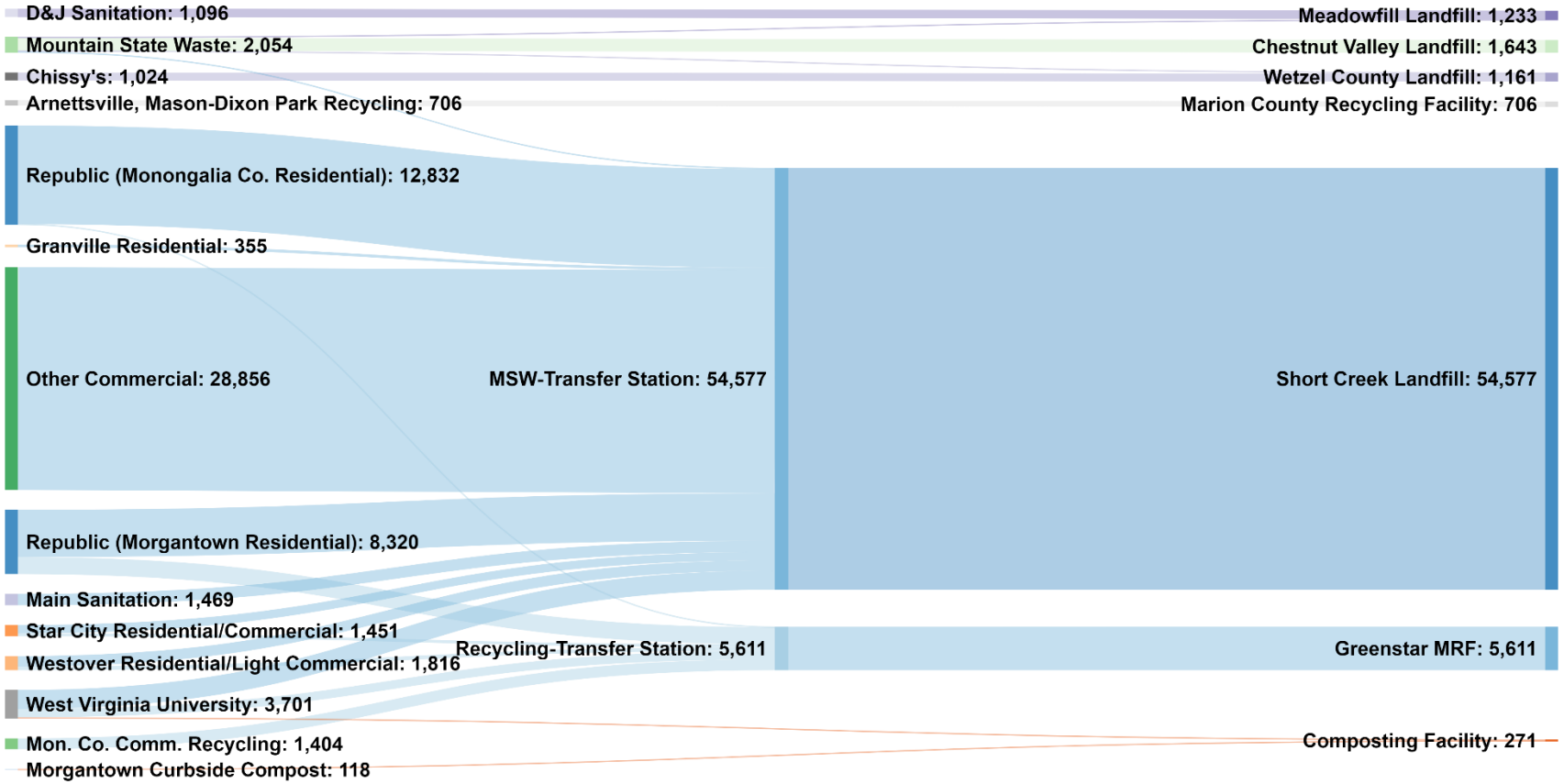
Recyclables trucked to Greenstar Recycling would increase by approximately 3,000 tons per year. While the Monongalia County Commission and Marion County Solid Waste Authority would double their recycling in this scenario, these programs would increase recycling by approximately 1,000 tons per year. The new composting facility would take only approximately 300 tons of compostable materials per year from Morgantown residents and WVU.

Table 1: Changes in flows in the Increased Recycling and Composting Scenario (tons/year)

	Change in flow
Reduction in MSW to landfills	
Short Creek Landfill via Mountaineer Transfer Station	-3,240
Chestnut Valley Landfill	-37
Meadowfill Landfill	-28
Wetzel County Landfill	-26
Total reduction in MSW to landfills	**-3,330**
Increase in recycling	
Direct to Mountaineer Transfer Station	2,005
Mon. Co. Comm. Recycling	702
Arnettsville, Mason Dixon Park Recycling	353
Total increase in recycling	**3,060**
Increase in composting	
Republic (Morgantown Residential)	118
West Virginia University	153
Total increase in composting	**271**

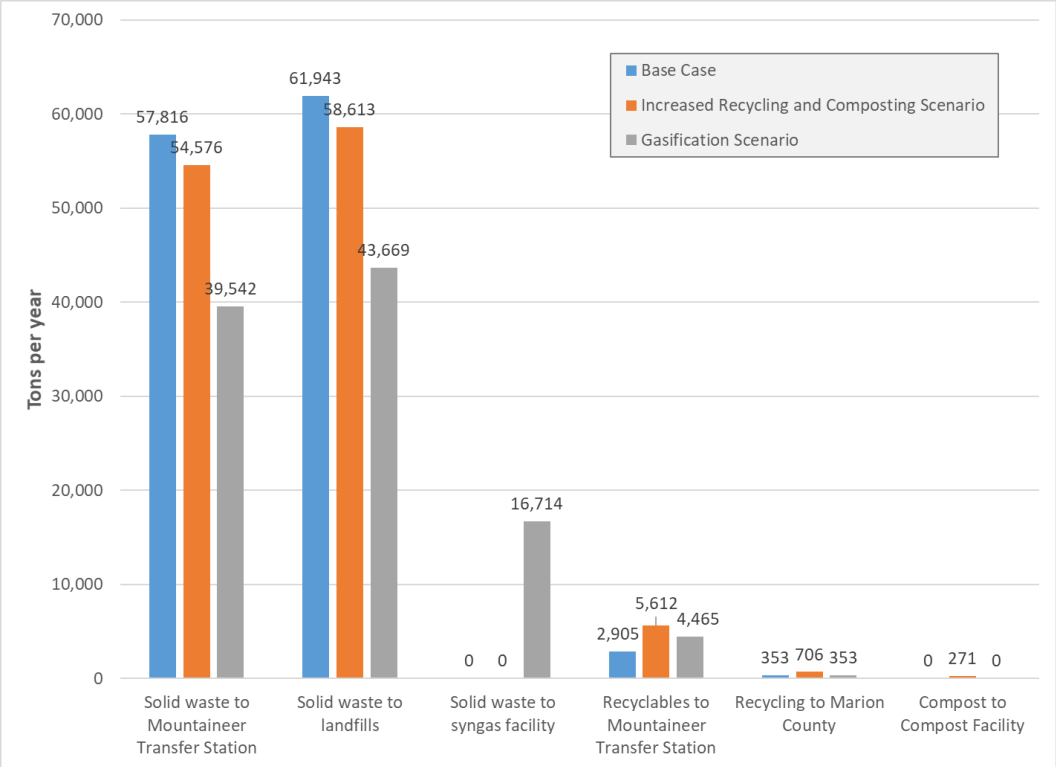
Source: Calculated in this report.

Figure 7: Flows of solid waste and recyclables in the Increased Recycling and Composting Scenario (tons per year)



Source: Calculated in this report.

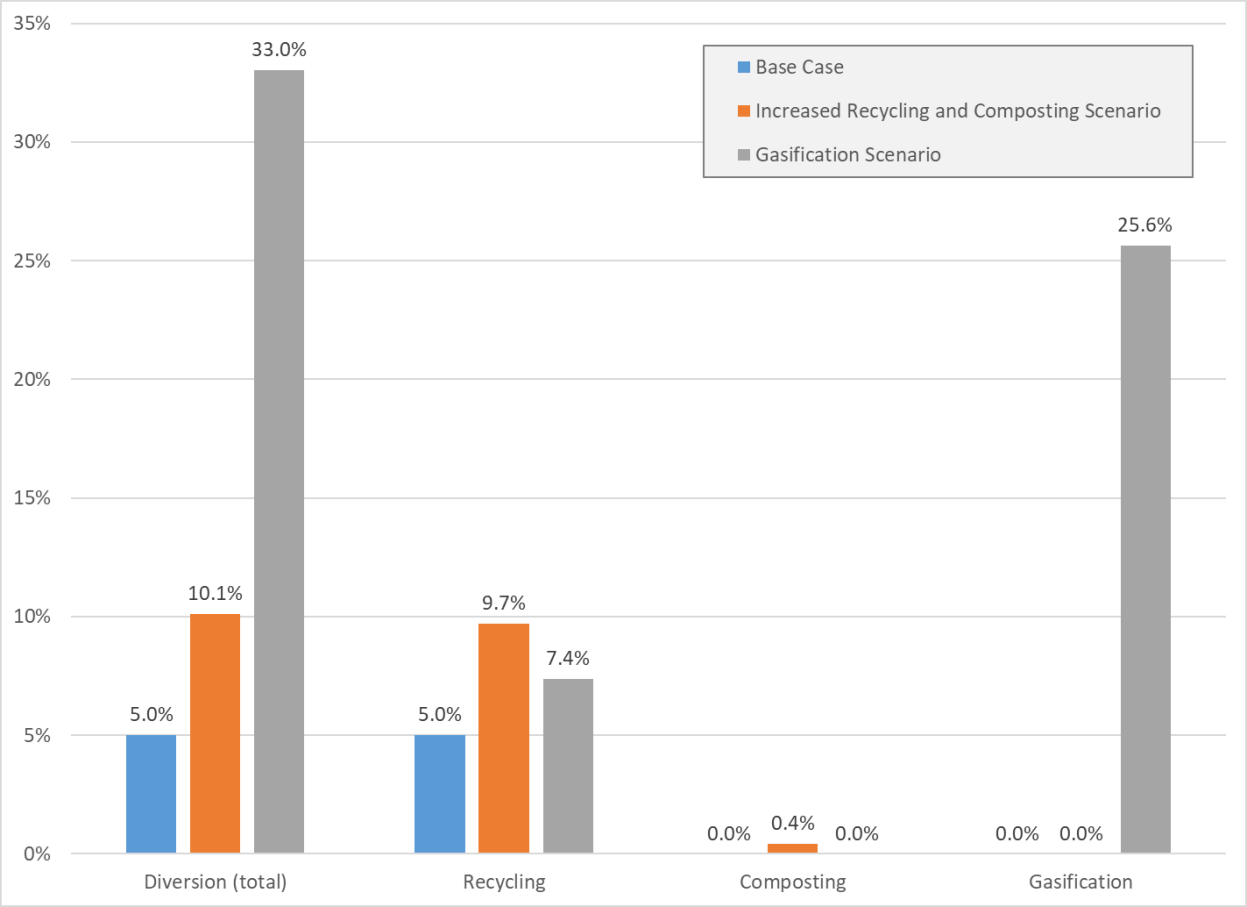
Figure 8: Changes in solid waste, recyclables, and composting flows across scenarios



Diversion rates for all three scenarios are illustrated in Figure 9. Even though the recycling rates in Morgantown, Star City, and Westover would increase to 26 percent and the recycling drop-off locations would double their recyclables, the county recycling rate would only increase from about 5 percent to 10 percent.

This underscores the importance of taking additional actions in the county, should there be a desire to approach the national average recycling rate of 26 percent county-wide. Expanding curbside, single-stream recycling to additional households beyond Morgantown, Star City, and Westover would likely be required.

Figure 9: Diversion rates across scenarios



4.2 Economic impacts

Customers in Morgantown, Star City, and Westover pay a certain amount of money each year for collection of MSW and recyclables, no matter how much they recycle. Increasing recycling rates to 26 percent in these municipalities would therefore not change the amount of money that customers pay to haulers. But with increased recycling, the haulers that service these three municipalities would save money because they would pay less per ton to dispose of recyclables ($35.00 per ton) as compared with MSW ($62.50 per ton).

For example, for each 1,000 tons of MSW and recyclables generated in Morgantown, approximately 100 tons are now recycled. The tipping fees paid at the MTS would total $59,750 ($62.50 per ton for MSW and $35.00 per ton for recyclables). If the recycling rate were to increase to 26 percent, then the hauler would save $4,400 in tipping fees.

A similar calculation performed for the entire amount of MSW and recyclables generated in the three single-stream communities suggests that haulers would save approximately $44,000 (Morgantown), $8,000 (Star City), and $11,000 (Westover), should residents of these communities recycle 26 percent of their waste. These savings represent a windfall for the current haulers. A portion of these savings could be used for public education to increase recycling rates or for other improvements to the municipalities' solid waste collection systems.

In this scenario, a total of 271 tons of organic material are diverted to a new compost program. The avoided tipping fees for this organic material, approximately $17,000 per year, represents a windfall to WVU and Republic Services, which would otherwise haul these materials to the MTS for disposal.

We model the new curbside compost program to be a voluntary program with a $60 annual fee for Morgantown customers that participate. This is a common arrangement within the industry. With this assumption, the curbside program would generate approximately $17,000 in annual fees from Morgantown residents.[5] If WVU were to pay a fee equal to its current tipping fee ($62.50 per ton), it would pay an additional $10,000 in annual fees to the composting operation. The operation would then receive approximately $27,000 plus any additional revenue generated from fees charged to residential and commercial drive-up customers, selling compost, or state or local government funding. Large producers of organic waste (such as landscaping companies, grocery stores, or restaurants) might generate significant revenues for a compost program because they would benefit from cost savings (via reduced tipping/disposal fees) and are in a better position to quickly implement a change to their disposal patterns.

The MTS would see a decrease in MSW but an increase in recyclables in this scenario, both of which would impact its bottom line. The decrease in MSW would result in a loss of approximately $203,000 in tipping fees, but the increase in recyclables would result in a gain of approximately $166,000 in tipping fees. Together, this represents a loss of approximately $37,000. However, the MTS would also increase the amount of cash received for recycling from Greenstar Recycling by approximately $17,000, which would partially offset the loss in tipping fees. Other self-reported data from Republic indicates that transportation of recyclables leads to a loss of revenue (Mountaineer Transfer Station, 2016); this would presumably continue into the future.

The estimated revenue changes calculated above are first-order approximations based on current tipping fees. Changes in flows of MSW and recyclables may trigger requests by landfills or the MTS to the West Virginia Public Service Commission for increases in tipping fees. As such, in the long term, revenues at those facilities may not change significantly if tipping fees are adjusted in the future.

4.3 Environmental impacts

In order to estimate the expected GHG implications of the Increased Recycling and Composting Scenario, it is necessary to consider which changes in flows will impact GHG emissions in a manner that is significant and measurable.

The top section of Table 2 documents the reduction in MSW sent to landfills. When less MSW is deposited in landfills, waste decomposition emissions decrease. Using the equations in Appendix A, GHG emissions will be reduced by 944 metric tons (MT) carbon dioxide equivalents (CO_2e) due to a reduction in waste decomposition alone. GHG emissions will be reduced at the landfills by an additional 55 MT CO_2e because landfill equipment emissions will also be reduced.

We estimate no net change in collection emissions, when considering the reduction in MSW together with the increase in recycling. For MSW that is now sent to the MTS, the same materials will be treated as recyclables and trucked to the same location. Transportation emissions from the MTS to the landfill, however, will be reduced due to the reduction in MSW sent to the Short Creek Landfill; this accounts for a reduction of 36 MT CO_2e. For MSW that is now sent to the other three landfills, the additional recyclables are captured at drop-off locations, and the collection emissions should not change. Transportation emissions to the landfills are estimated to drop by a very small amount, bringing the total reduction in transportation emissions to 37 MT CO_2e. In total, the reduction in MSW sent to landfills will reduce GHG emissions by an estimated 1,036 MT CO_2e.

[5] It is a coincidence that the $17,000 in annual fees from Morgantown residents is the same as the $17,000 in avoided tipping fees for the organic waste diverted from WVU.

The middle section of Table 2 documents the GHG implications regarding the increase in recycling. The additional tonnage of recycling in this scenario results in an increase in GHG emissions related to transportation of 34 MT CO_2e.

Finally, the bottom section of Table 2 documents the GHG implications regarding the increase in composting. When organic matter is composted, CH_4 production is avoided; these avoided CH_4 emissions are accounted for in the GHG reductions associated with waste decomposition at the landfills, discussed above. The CO_2 released during composting is considered to be biogenic and is not considered in GHG calculations (U.S. Composting Council, 2008). Increased emissions, totaling 5 MT CO_2e, are estimated for the collection of the compost and delivery to the composting facility.

In total, accounting for both the reductions and increases in GHG emissions, it is estimated that the Increased Recycling and Composting Scenario would reduce GHG emissions by approximately 1,000 MT CO_2e.

Table 2: Greenhouse gas implications for the Increased Recycling and Composting Scenario (MT CO_2e)

	Waste decom-position	Landfill equipment	Collection	Transporta-tion (to landfill or MRF)	Total
Reduction in MSW to landfills					
Short Creek Landfill via MTS	-919	-53	0	-36	-1,008
Chestnut Valley Landfill	-10	-1	0	-<1	-11
Meadowfill Landfill	-8	-<1	0	-<1	-8
Wetzel County Landfill	-7	-<1	0	-<1	-8
Total reduction in MSW to landfills	**-944**	**-55**	**0**	**-37**	**-1,036**
Increase in recycling					
Direct to MTS	0	0	0	22	22
Mon. Co. Comm. Recycling	0	0	0	8	8
Arnettsville, Mason Dixon Park Recycling	0	0	0	4	4
Total increase in recycling	**0**	**0**	**0**	**34**	**34**
Increase in composting					
Republic (Morgantown Residential)	0	0	2	0	2
West Virginia University	0	0	3	0	3
Total increase in composting	**0**	**0**	**5**	**0**	**5**
TOTAL	**-944**	**-55**	**5**	**-3**	**-996**

Source: Calculated in this report.

4.4 Key observations

- Even though the recycling rates in Morgantown, Star City, and Westover would increase to 26 percent and the recycling drop-off locations would double their recyclables in this scenario, the countywide recycling rate would only increase from about 5 to 10 percent. This underscores the importance of expanding recycling services countywide.
- One method for increasing countywide recycling rates would be to improve participation in the current curbside, single-stream recycling programs in Morgantown, Star City, and Westover, as modeled in this scenario.
- A second method for increasing countywide recycling rates would be to increase the number of drop-off recycling locations and/or to increase the number of days and hours that current drop-off locations are open, as modeled in this scenario.

- A third method for increasing countywide recycling rates would be to expand curbside, single-stream recycling to additional households outside of Morgantown, Star City, and Westover; this is not modeled in the Increased Recycling and Composting Scenario.
- Increasing the recycling rates to the national average in the three single-stream communities would save haulers approximately $44,000 (Morgantown), $8,000 (Star City), and $11,000 (Westover). These savings represent a windfall for the current haulers.
- The composting facility modeled in this scenario would be small, diverting a total of 271 tons of organic materials from Morgantown residents and from WVU, with potential revenues totaling approximately $27,000 per year. Additional revenue from residential and commercial drive-up customers, from selling compost, or from state or local government funding would also be required.
- In total, accounting for both the reductions and increases in GHG emissions, it is estimated that the Increased Recycling and Composting Scenario would reduce GHG emissions by approximately 1,000 MT CO_2e.

5. THE GASIFICATION SCENARIO

The second potential future scenario models the construction of a PEF manufacturing facility and a linked gasification plant to turn the PEF into syngas and then electricity. The gasification plant is modeled on the 420-kilowatt Aries Clean Energy Facility in Tennessee; however, it is fueled by MSW converted to PEF.

In this scenario, approximately 17,000 tons of MSW are diverted to fuel the gasification plant, and an additional approximately 1,500 tons of MSW are converted to recyclables during the process of generating PEF. This represents 28% of the county's total waste stream. The modeled plant also takes approximately 1,000 tons of tires per year. Based on a comparison with the Tennessee facility, the plant would generate approximately 2,000 megawatt-hours of electricity per year.[6]

The most practical way for a syngas plant to sell its electricity in West Virginia is to net meter with a single, large electricity customer. West Virginia allows net metering, in which certain types of energy resources, including syngas, can be installed on the customer side of the meter to generate electricity.[7] When more electricity is needed than is generated by the customer, it is purchased from the grid and the meter runs forward. But when generation exceeds the customer's demand, it is sold back to the grid and the meter runs backward. Net metering is limited to 2 megawatts for industrial customers and 500 kilowatts for commercial customers; the envisioned 420-kilowatt plant falls within both of these limitations.

5.1 Changes in flows

Table 3 summarizes the changes in flows in the Gasification Scenario, as compared with the Base Case Scenario. These changes are also illustrated in Figure 10 (below). Figure 8 (above) compares the Base Case with the Increased Recycling and Composting Scenario and the Gasification Scenario. Diversion rates for all three scenarios are illustrated above in Figure 9.

The Gasification Scenario would reduce the amount of MSW sent to the MTS by approximately 18,000 tons per year. Recyclables trucked to Greenstar Recycling would increase by approximately 1,500 tons per year, and approximately 17,000 tons per year of MSW would be converted to PEF and, ultimately, syngas.

5.2 Economic impacts

Haulers would only truck MSW to the PEF/gasification facilities if they could save money—meaning that the tipping fee and transportation costs were lower than what is now incurred. As mentioned above, the MSW tipping fee at the MTS is currently $62.50. If 17,000 tons of MSW were diverted from the MTS to the PEF/gasification facilities at the same $62.50 tipping fee, then approximately $1 million less would be spent at the MTS. This would represent an annual loss to the MTS and an annual gain to the PEF/gasification facilities.

As discussed above in Section 3.3, gasification facilities are high-risk investments; no commercially operating gasification plants fueled by MSW have been identified in the United States or Canada. For this reason, any economic impact is unpredictable.

As discussed above, the most practical way for a syngas plant to sell its electricity in West Virginia is to net meter with a single, large electricity customer. A challenge, however, is that electricity generated by the syngas plant would need to compete with the low electricity rates typically paid by large industrial customers. Industrial customers pay a per-kilowatt-hour rate and a demand charge. If the syngas plant sold its electricity for 3 cents/kilowatt-hour, it would only generate approximately $66,000 in electricity sales—a small amount

[6] This is based on the facility running five days per week, or 260 days per year, like the Aries Clean Energy Facility in Tennessee.
[7] W.Va. Code of State Rules §150-33.

compared to the estimated $1 million in tipping fees. This suggests that tipping fees, and not electricity sales, are a much more important factor regarding the PEF/syngas facilities' financial stability.

Table 3: Changes in flows in the Gasification Scenario (tons/year)

	Change in flow
Reduction in MSW to landfills	
Short Creek Landfill via Mountaineer Transfer Station	-18,274
Chestnut Valley Landfill	0
Meadowfill Landfill	0
Wetzel County Landfill	0
Total reduction in MSW to landfills	**-18,274**
Increase in recycling	
Direct to Mountaineer Transfer Station	1,560
Mon. Co. Comm. Recycling	0
Arnettsville, Mason Dixon Park Recycling	0
Total increase in recycling	**1,560**
Increase in syngas	
Republic (Monongalia Co. Residential)	10,576
Republic (Morgantown Residential)	6,139
Total increase in syngas	**16,714**

Source: Calculated in this report.

5.3 Environmental impacts

Table 4 documents the GHG implications for the Gasification Scenario—some of which are known, and some of which are unknown.

The reduction in GHG emissions associated with waste decomposition and equipment at the landfill and transportation of MSW to the landfill is much higher in the Gasification Scenario than the Increased Recycling and Composting Scenario, because more waste is diverted from landfills.

A small increase in transportation emissions, associated with the increase in recycling, partially offsets the aforementioned decrease in GHG emissions.

The GHG implications of the PEF and syngas facilities themselves, however, are unknown. It was simply not possible to collect the data needed to estimate this value, despite the availability of some information from the Entsorga WV PEF facility in West Virginia and the Aries Clean Energy facility in Tennessee. Among other challenges, the Aries facility utilizes different feedstocks than the MSW contemplated in the Gasification Scenario. Entsorga WV represents that its facility will result in a net reduction in GHG emissions (Carollo, 2017); however, this calculation could not be independently verified.

Because the GHG implications of the PEF and syngas facilities themselves are unknown, the total GHG implications for the Gasification Scenario cannot be estimated. If the PEF and syngas facilities, together, increase GHG emissions by less than 5,668 MT CO_2e, then this scenario would be estimated to reduce GHG emissions in total. If, however, these facilities would increase GHG emissions by more than this amount, then the Gasification Scenario would lead to an increase in GHG emissions, in total.

Table 4: Greenhouse gas implications for the Gasification Scenario (MT CO_2e)

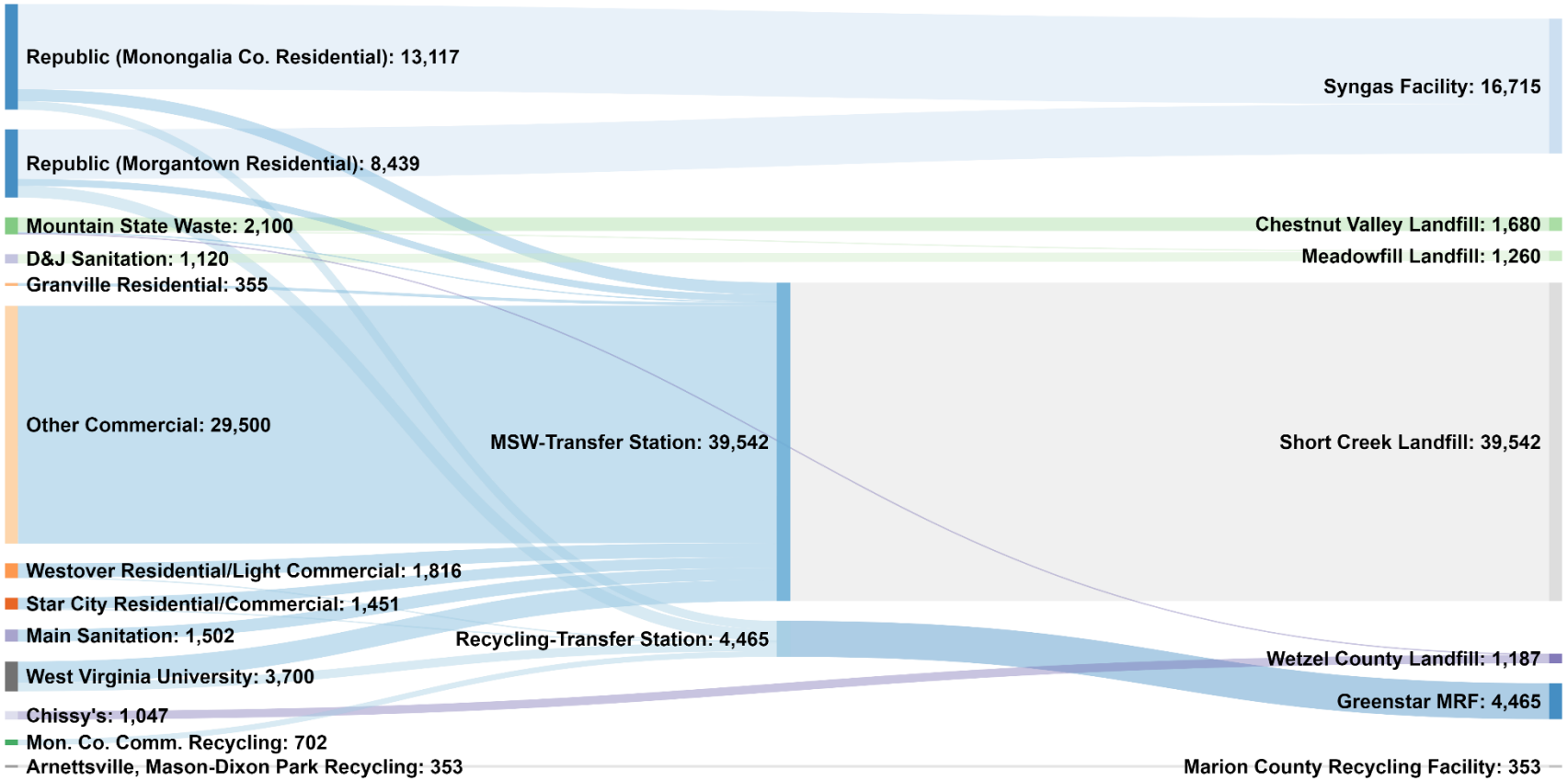
	Waste decom-position	Landfill equipment	Collection	Transporta-tion (to landfill or MRF)	PEF/Syngas facility	Total
Reduction in MSW to landfills						
Short Creek Landfill via MTS	-5,181	-300	0	-205	0	-5,685
Chestnut Valley Landfill	0	0	0	0	0	0
Meadowfill Landfill	0	0	0	0	0	0
Wetzel County Landfill	0	0	0	0	0	0
Total reduction in MSW to landfills	**-5,181**	**-300**	**0**	**-205**	**0**	**-5,685**
Increase in recycling						
Direct to MTS	0	0	0	17	0	17
Mon. Co. Comm. Recycling	0	0	0	0	0	0
Arnettsville, Mason Dixon Park Rec.	0	0	0	0	0	0
Total increase in recycling	**0**	**0**	**0**	**17**	**0**	**17**
Increase in syngas						
Republic (Monongalia Co. Res.)	0	0	0	0	Unknown	Unknown
Republic (Morgantown Residential)	0	0	0	0	Unknown	Unknown
Total increase in syngas	**0**	**0**	**0**	**0**	Unknown	Unknown
TOTAL	**-5,181**	**-300**	**0**	**-188**	Unknown	Unknown

Source: Calculated in this report.

5.4 Key observations

- Compared with the Increased Recycling and Composting Scenario, the Gasification Scenario results in the diversion of significantly more MSW from landfills.
- Due to the recycling that is removed from the waste stream at the PEF facility, the Gasification Scenario also results in an increase in recycling of approximately 1,500 tons per year, as compared with the Base Case Scenario. Paradoxically, this increase is more than half of the increase in recycling in the Increased Recycling and Composting Scenario.
- Gasification facilities are high-risk investments; therefore, any economic impact is unpredictable.
- If haulers diverted 17,000 tons of MSW to the PEF/gasification facilities at the same $62.50 tipping fee that is currently paid to the MTS, then approximately $1 million would be spent at the PEF/gasification facilities. This would be the primary annual funding source for the PEF/gasification facilities.
- These funds, however, would be diverted from the MTS, significantly reducing its annual income stream.
- Generating electricity for sale in West Virginia is a challenge and would require that this project be integrated with a single net-metered customer, so as to avoid being regulated as an electric utility. It is also a challenge in West Virginia due to the low electricity costs charged to industrial customers.
- If the syngas plant sold its electricity for 3 cents/kilowatt-hour, it would only generate approximately $66,000 in electricity sales—a small amount compared to the estimated $1 million in tipping fees. This suggests that tipping fees, and not electricity sales, are a much more important factor regarding the PEF/syngas facilities' financial stability.
- The total GHG implications for the Gasification Scenario cannot be estimated, and will depend on whether increased GHG emissions from the PEF and syngas facilities exceed the reduction in GHG emissions attributed to the increased recycling in this scenario.

Figure 10: Flows of solid waste and recyclables in the Gasification of Solid Waste Scenario (tons per year)



Source: Calculated in this report.

6. CONCLUSIONS AND RECOMMENDATIONS

This report presents three scenarios for comparison:

1. **the Base Case Scenario,** which describes current MSW and recycling flows,
2. **the Increased Recycling and Composting Scenario,** which increases recycling and adds composting, and
3. **the Gasification Scenario,** which diverts MSW to a gasification facility.

Key observations are included above for the Base Case Scenario (Section 2.5), Increased Recycling and Composting Scenario (Section 4.4), and Gasification Scenario (Section 5.4).

6.1 Conclusions

Conclusions learned from the results of these three scenarios, and from discussions with key stakeholders during the course of this research, are highlighted below.

Recycling rates can be dramatically increased. Currently, Morgantown, Star City, Westover, and WVU have instituted single-stream recycling programs; other residents who choose to recycle must take recyclables to a drop-off location. Only an estimated 5 percent of the county's total waste is recycled. Recycling rates are estimated to be 10 percent in Morgantown, 7 percent in Star City, and 4 percent in Westover. For comparison, an estimated 26 percent of MSW is recycled across the country.

Long-term recycling options for county residents outside of Morgantown, Star City, Westover should be considered. The Monongalia County Commission provides important drop-off recycling options to county residents. However, it spends a significant amount of resources on this effort, and these sites are largely run via volunteer labor. It may be difficult to sustain the program into the future, particularly if the program were expanded to serve additional county residents.

The current recycling drop-off locations subsidize haulers. Each ton of recyclables that county residents take to drop-off locations represents one fewer ton collected by haulers, which otherwise would need to haul and pay tipping fees for the un-recycled waste. The recyclables diverted by the Monongalia County Commission's recycling program represent a subsidy of approximately $44,000 to haulers, and those diverted by the Marion County Solid Waste Authority's program represent a subsidy of approximately $22,000.

Increasing recycling and composting would generate additional subsidies to haulers. Increasing the recycling rates to the national average in the three single-stream communities would save haulers approximately $44,000 (Morgantown), $8,000 (Star City), and $11,000 (Westover).

New savings could be used to further improve the county's solid waste management system. Savings could be used, for example, for public education to increase recycling rates.

Building PEF/gasification facilities would help increase the county's recycling rate. Certain types of recyclables must be retrieved during the PEF conversion process, thereby increasing the county's recycling rate.

Gasification facilities are high-risk investments; therefore, any economic impact is unpredictable. No commercially operating gasification plants fueled by MSW have been identified in the United States or Canada, with the most notable example being a facility in Ontario, Canada that is now out of business.

The PEF/gasification facilities considered in this report would divert a large amount of waste from landfills and from the MTS. In the Gasification Scenario, approximately 17,000 tons of MSW are diverted to fuel the gasification plant, and an additional approximately 1,500 tons of MSW are converted to recyclables during the process of generating PEF. This is about 28% of the county's total waste stream.

Tipping fees, and not electricity sales, are a much more important factor regarding the PEF/syngas facilities' financial stability. The PEF/gasification facilities considered in this report could generate tipping fees of approximately $1 million per year, as compared to electricity valued at only $66,000.

Coordination among local governments, under the leadership of the MCSWA, could generate efficiencies. Municipalities, the Monongalia County Commission, and private haulers now operate independently. Coordinated efforts—including, for example, joint advertising of recycling options—could help divert additional MSW from landfills in a cost-effective manner. The MCSWA would be a natural entity to play a leadership role in this effort.

6.2 Implementation recommendations

Implementation of changes to the solid waste system are just as important as the ideas themselves; a badly implemented strategy will pay no dividends. Fortunately, even the less-established strategies—such as curbside collection of organic waste—are widespread enough that the "rules of the road" are well established.

6.2.1 *Data collection*

One of the most important lessons from the review of solid waste management plans in Austin, Montgomery County, and central Ohio can be summarized in a single word: data. The biggest difference between these entities and Monongalia County is the volume of data and metrics that they possess and we do not. These data are absolutely vital to informed decision-making, and without a clear understanding of the state of the current solid waste management system, it is difficult to assess the effectiveness of any new program.

As an example, this report highlights the low recycling rates in Monongalia County, where were estimated given available information on recycling and MSW tonnages. Unfortunately, this information does not allow for a meaningful discussion of participation rates. We found no information on the total number of households using the curbside service within in the single-stream municipalities, for example. Complete information on this and other subjects is vital if MCSWA, municipalities, or the Monongalia County Commission are to implement effective policies and assess the effectiveness of those policies.

This project required a substantial amount of data collation and estimation, and a number of key pieces of information were available from existing sources. However, at present, they are not compiled in an organized manner, making any analysis difficult. At a minimum, we recommend compiling all available monthly reports from the MTS and the pertinent landfills into a format that allows for the creation of trend reports. The City of Morgantown also receives information from Republic for monthly recycling totals, and this information can easily be compiled alongside data from the Monongalia County Commission's recycling program.

A secondary goal, but of equal importance, is to work with the MTS, haulers, and the Marion County Solid Waste Authority to compile additional monthly data.

6.2.2 *Improving and expanding recycling*

The volume of existing documentation describing strategies to increase recycling rates is massive, but it essentially boils down to two key points: (1) increase opportunities and (2) communicate clearly with the target audience.

Improving recycling rates in Monongalia County will require multiple methods, depending on the target audience. As noted in our model, three municipalities now offer single-stream, curbside recycling. Presently, these municipalities have recycling rates far below the national average. We offer several strategies for increasing the diversion rate in Morgantown, Star City, and Westover.

- Ensure that all households receive bins; according to Republic Services, just 53 percent of the customers within the City of Morgantown have bins (McWilliams, 2017) . All customers are automatically enrolled in recycling, a very important first step for a successful recycling program, but this positive step is severely undermined by not providing bins.
- Similarly, commercial customers within Republic's service areas have fee-based recycling resources available to them now, but anecdotal evidence suggests these are rarely utilized. This could have a large impact on recycling participation because many of these "commercial" customers are, in fact, high-density residential buildings; many of Morgantown's apartment dwelling residents do not have access to curbside recycling, despite living within city limits. More research into participation levels by this type of customer would be valuable, as would outreach to these entities in order to encourage use of these services.
- One of the key findings of the 2016 "State of Recycling" report from The Recycling Partnership is that the most successful curbside recycling programs included actions from local governments to incentivize or otherwise improve recycling. This can be achieved through various methods, such as working to build contracts with vendors that guarantee recycling, or engaging in vigilant accounting of those vendors to ensure that services are up to contractual standards. (The Recycling Partnership, 2017)
- Education and outreach is a vital element to recycling participation. Anecdotal evidence suggests that many residents of single-stream municipalities are still unsure about what they can and cannot recycle, opting instead to simply not participate.
- Community engagement can play a role, such as having a representative available at community events to provide information and answer questions about recycling.
- "Pay as You Throw" rate structures, in which waste volumes exceeding that which fits within a provided container will result in an additional fee—have been demonstrated to be very effective in encouraging customers to divert eligible waste away from the landfill stream. This would require a substantial change to existing systems, but engaging those municipalities that have independent contracts and/or internal waste hauling programs about these options is a good first step in a move towards incentivized diversion.

In other parts of the county, increasing recycling will require creating new opportunities for those residents to recycle. One of the elements modeled in the Increased Recycling and Composting Scenario is an increase in recycling by the Monongalia County Commission and the Marion County Solid Waste Authority. These two programs are the sole resources for most of the county and, through no fault of the two entities in question, the capacity and extent of those offerings is far from sufficient to meet the needs of residents. The increase we have modeled—a doubling of capacity for both the Monongalia County Commission and Marion County Solid Waste Authority programs—is extremely small.

Any significant increase in recycling services for those areas will require a far greater increase in services. This is a real challenge, and will require leadership, coordination, and creative thinking. Anecdotal evidence

suggests that residents in many regions of the county would like curbside recycling to be part of their services, but implementing curbside recycling will require leadership and coordination.

6.2.3 *Implementing diversion of organics*

The Increased Recycling and Composting Scenario also models a hypothetical curbside organic collection program, but a program of that nature should be thought of as a starting point rather than a final destination. Diversion of household organics is an important goal, but the earliest steps to implement a composting program should target large producers of organic waste who will both benefit from cost savings (via reduced tipping/disposal fees) and are in a better position to quickly implement a change to their disposal patterns. On the face of it, cost savings are simple enough to offer: smaller tipping fees for those currently delivering organic material to the transfer station (e.g., landscaping companies) and lower disposal costs for large disposers of organic materials (e.g., grocery stores and restaurants). In reality, the complexities of starting a compost enterprise that, at a minimum, breaks even, are significant.

A simple first step in this process is engaging WVU, which has expressed a strong interest in diverting compostable waste from the Morgantown Campus' four dining halls away from the landfill and into a compost facility. Research into the management and costs of WVU's and Morgantown's current green/yard waste activities was not part of this project, but these are certainly areas to explore for potential public/private partnerships wherein costs may be diverted away from WVU or the City in order to help start-up a composting operation.

Composting organic materials rather than placing them in the regular waste stream is a significant change that has the potential to drastically decrease the volume of waste going to landfill. It would be naïve to think that a change of this magnitude will happen overnight, but other locales around the United States, and Europe, have demonstrated that curbside composting is a viable option. Successful implementation will require a measured approach and numerous strategies. Austin, for example, has opted to lead by example, implementing food waste and compostable material collection at all City buildings. As noted in the recycling section, volume-based fee structures have proven to be effective at encouraging diversion away from the landfill waste stream. In nearly all cases researched for this project, implementation of a curbside compost program began with a pilot project and coordinated education and outreach programs.

6.2.4 *Solid waste gasification*

The highest impact way of diverting MSW away from landfills is an PEF manufacturing facility paired with an PEF-fired gasifier. This is also the highest cost and most difficult addition to the solid waste management landscape. Challenges are myriad: the costs are very high, the technology is largely unproven, West Virginia's regulatory environment makes the prospect of operating an electric utility a non-starter, and navigating public perception to facilities of this type will be challenging.

The cost of equipment and construction for a syngas facility like the Lebanon, Tennessee facility would be approximately $21 million (Snyder, 2017). We do not estimate the cost of an PEF plant large enough to feed this facility; however, the plant under construction in Martinsburg, West Virginia has at least $25 million in funding (Waste Today, 2016).

A project of this nature would likely involve numerous public and private partners. Depending on the makeup of that partnership, redirecting such a large volume of MSW would likely have a disruptive effect on the flow of solid waste monies within the county. Financial success of any solid waste facility, in fact, depends on tipping fees, meaning that any new MSW facility would either directly compete with the MTS, or be part of the MTS.

6.3 The role of the Monongalia County Solid Waste Authority

As mentioned above, coordination among local governments and private haulers could help drastically increase recycling and composting rates and could help facilitate the construction of an PEF/gasification facility, should it prove to be cost-effective. The MCSWA would be a natural entity to play a leadership role in this effort.

To begin this process, it is recommended that the MCSWA share the results of this study widely and begin a discussion with local stakeholders regarding a common, long-term vision for Monongalia County's solid waste management system.

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APPENDIX A: GREENHOUSE GAS EMISSION EQUATIONS

Waste decomposition emissions

The waste disposed during any one year will generate emissions over a long period of time. Waste decomposition emissions were estimated using the following equation:

$$CH_4\ emissions\ = (1 - CE) \times (1 - OX) \times M\ \times EF \times GWP_{CH4}$$

Source: ICLEI (2012).

Where:

- CH_4 emissions = Waste decomposition emissions (MT CO_2e/year)
- CE = Default landfill gas collection efficiency (0.75)
- OX = Oxidation rate (0.1)
- M = Total mass of solid waste entering landfill (wet short tons/year)
- EF = Emission factor for mixed residential and commercial waste (0.06 MT CH_4/wet short ton)
- GWP_{CH4} = Global warming potential (21 MT CO_2e/MT CH_4)

Landfill equipment emissions

Equipment at the landfill generates CO_2 emissions. Republic Services only uses diesel engines for its operations, as opposed to natural gas or gasoline engines. Assuming that diesel engines are also used at the other landfills, the following equation was used to calculate landfill equipment emissions:

$$Landfill\ equipment\ emissions = M \times EF$$

Source: ICLEI (2012).

Where:

- Landfill equipment emissions = Total landfill equipment emissions (MT CO_2e/year)
- M = Total mass of solid waste entering landfill (wet short tons/year)
- EF = Emission factor for landfill equipment emissions (0.0164 MT CO_2e/wet short ton)

Collection emissions

Collection emissions are predominately CO_2 emissions associated with powering the equipment necessary to collect solid waste from within the community. The following equation was used to calculate collection emissions:

$$Collection\ emissions = M \times EFC$$

Source: ICLEI (2012).

Where:

- Collection emissions = Total collection emissions (MT CO_2e/year)
- M = Total mass of solid waste collected and transported and entering landfill (wet short tons/year)
- EFC = Emission factor for collection emissions (0.02 MT CO_2e/wet short ton)

Transportation emissions

Transportation emissions cover the transportation of waste from the community to the landfill. The following equation was used to calculate transportation emissions:

$$Transportation\ emissions = M \times Miles\ travelled \times EFT$$

Source: ICLEI (2012).

Where:

- Transportation emissions = Total transportation emissions (MT CO_2e/year)
- M = Total mass of solid waste collected and transported and entering landfill (wet short tons/year)
- Miles traveled = Distance from the community to the landfill (80 miles for the Short Creek Landfill)
- EFT = Emission factor for transport emissions (0.00014 MT CO_2e/wet short ton/mile)