Technology Assessment
Solid Waste Master Plan
Task 6
Pinellas County, Florida
May 2019
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1 Introduction

Pinellas County (the County) has an integrated solid waste management system in place with several key existing assets that will continue to play a critical role in meeting the waste management requirements over the planning period. The purpose of Task 6, Technology Assessment, is to evaluate the potential expansion/modification of certain existing assets, as appropriate. This assessment also provides an overview of applicable technologies that have the potential to increase diversion in an environmentally sound manner, providing potential economic and energy efficient alternatives, including a list of advantages and disadvantages. Based on a review of the system elements and potential strategies detailed in Task 5, Needs Assessment, a list of potential strategies to be considered as part of the technology assessment was prepared. Section 2 of this report provides a summary of potential strategies covered in the remaining sections of this report.

This report will help inform which case studies will be conducted in Task 7 (Case Studies). The results of this Task 6, along with Task 7, will inform which strategies will be included in Task 8 (Scenario Development and Testing), which will include further research of the strategies deemed appropriate for further consideration.

The remainder of this report is organized in sections addressing the identified system elements and waste management technologies.
2 Summary of Strategies Included in Technology Assessment

Based on the Task 5 Needs Assessment, the following potential strategies were identified and included in this technology review:

1) Expansion of the usable capacity of the existing landfill
   a. Mechanically stabilized earth (MSE) walls
   b. Expansions
2) Traffic improvements at the existing site
3) Improvements to the waste-to-energy (WTE) facility
   a. Tip floor
   b. Expansion
   c. Pit storage
4) Storage of waste during high volume/outages
5) Reducing in-house power/increase gross to the grid
6) On site transfer station
7) Ash management
   a. Metals cleaning facility
   b. Enhanced metals processing facility
   c. Regional metals processing facility
   d. Identify best option (in the building, separate facility, combined versus separate)
8) Bulky waste processing facility
9) Explore use of closed Toytown Landfill
10) Adequate public/private sector recyclables processing capacity
11) Use of existing anaerobic digester (AD) wastewater treatment plant (WWTP) capacity for organics

In addition, this report also summarizes the status of other current waste management technologies that may, or may not, have applicability to Pinellas County.
3 Technology Assessment

3.1 Expansion of Usable Capacity of the Existing Landfill

3.1.1 MSE Walls
WTE ash disposed is oftentimes placed using traditional filling techniques in permitted disposal areas with sideslopes typically of 3 horizontal to 1 vertical, similar to that of municipal solid waste (MSW) landfills. However, by integrating a portion of the ash that is produced at the WTE facility into an alternative use as an alternate construction material, the disposal area can realize significant additional airspace by re-designing and re-developing the sideslopes as a vertical expansion utilizing a mechanically stabilized berm design along sections of, or around the entire perimeter of, the disposal area.

A mechanically stabilized berm is a constructed feature that, due to its inherent properties, allows a steeper exterior slope, often approaching 1 horizontal to 3 vertical. In MSW landfills, most mechanically stabilized berms are made of compacted soils and high density polyethylene (HDPE) geogrid. Geogrid is laid onto the surface and wrapped over the face of the wall. An additional layer of geogrid is placed and covered with compacted soil and the subsequent geogrid is again wrapped over the face of the wall. This layering continues to the desired and designed height. All geogrid wrapping occurs along the exterior face. The resulting gain in landfill height with minimum horizontal expansion allows increased landfill capacity as a vertical expansion. Ash generated at the WTE facility could be processed for use as a replacement for soil when building the mechanically stabilized berm. The HDPE geogrid is compatible with the WTE ash, and the processed ash has properties similar to soil that allow it to be suitable for mechanically stabilized (MS) berm construction and long-term performance.

The berm can be constructed as part of operations by shifting daily operations away from external slopes during berm construction. Using the WTE ash as a building material within the landfill boundary gives the material a secondary beneficial use by increasing air-space through diversion, optimizing the capacity of the permitted footprint, and extending the site-life of the landfill.

By incorporating the construction of the mechanically stabilized berms as part of current landfill operations, one can achieve airspace increases for each ton of ash used in the berm construction. The physical properties of the processed ash can be utilized as structural fill in both the reinforced as well as the retained fill areas within the mechanically stabilized berm – thereby creating significant airspace by constructing a stable and nearly vertical face with the processed ash product as it is generated at the WTE plant.

The additional airspace that could potentially be realized depends on the dimensions of the berm and any pre-existing height limits that the disposal facility may be under. Costs of berm development depend on the costs involved in any additional material processing and handling. However, to illustrate how the inclusion of an MS berm can influence the costs and revenues of a disposal facility, Table 3.1 below from a previous feasibility study presents a summary of projected costs of a 40-foot soil berm permitted along section of a 62-acre Florida waste
disposal facility. In this study, Expansion Option 1 is the MS Berm Design Option and Expansion Option 2 is the Traditional Expansion Design Option (conventional sideslope design). The cost data presented are based on off-site borrow soil and was used for comparisons of the two options. Actual costs for both options could vary due to inflation since this table was prepared.

**Table 3.1 MS berm cost comparison**

<table>
<thead>
<tr>
<th>Evaluation Factor</th>
<th>Expansion Option</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Area and Disposal Capacity Summary:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total Area (acres)</td>
<td>62</td>
<td>62</td>
</tr>
<tr>
<td>Disposal Capacity (cy)</td>
<td>11,669,000</td>
<td>9,080,000</td>
</tr>
<tr>
<td>Disposal Capacity (tons)</td>
<td>8,751,750</td>
<td>6,810,000</td>
</tr>
<tr>
<td>Construction Cost Summary:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total Initial Construction Cost</td>
<td>$26,000,741</td>
<td>$15,802,366</td>
</tr>
<tr>
<td>Total Closure Construction Cost</td>
<td>$7,069,489</td>
<td>$7,069,489</td>
</tr>
<tr>
<td>Total Initial Construction Engineering Cost</td>
<td>$3,004,214</td>
<td>$2,400,000</td>
</tr>
<tr>
<td>Total Closure Engineering Cost</td>
<td>$2,604,214</td>
<td>$2,604,214</td>
</tr>
<tr>
<td>Contingencies</td>
<td>$6,614,046</td>
<td>$4,574,371</td>
</tr>
<tr>
<td>Landfill Mining</td>
<td>$12,000,000</td>
<td>$12,000,000</td>
</tr>
<tr>
<td>Total Construction, Mining and Engineering Cost</td>
<td>$57,292,704</td>
<td>$44,450,440</td>
</tr>
<tr>
<td>Cost Analysis:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total Development Cost/Acre of Landfill Area</td>
<td>$924,076</td>
<td>$716,943</td>
</tr>
<tr>
<td>Total Development Cost per cy of Waste</td>
<td>$4.91</td>
<td>$4.90</td>
</tr>
<tr>
<td>Total Development Cost per ton of Waste</td>
<td>$6.55</td>
<td>$6.53</td>
</tr>
<tr>
<td>Total Initial Development Cost/Acre</td>
<td>$467,822</td>
<td>$293,587</td>
</tr>
<tr>
<td>Total revenue @ $31/ton of waste</td>
<td>$271,304,250</td>
<td>$211,110,000</td>
</tr>
<tr>
<td>Gross Income</td>
<td>$214,011,546</td>
<td>$166,659,560</td>
</tr>
</tbody>
</table>

The table above indicates that the berm is feasible under these conditions. However, a site-specific feasibility study and conceptual design must be performed to determine the feasibility of MS berms as a design option for disposal facility expansion.

Working to optimize the footprints of currently-permitted landfills can reduce the need of siting new disposal sites or horizontally expanding existing sites. With this innovative engineering solution, post combustion residuals such as WTE ash can be utilized as construction materials to build reinforced berms/walls within the permitted waste footprint of existing landfills. For WTE disposal facilities this innovation identifies a reuse option for using some of the ash generated and reusing it in such a way as to increase the value of those facilities by significantly increasing airspace over a given permitted footprint without the expense of importing soils to construct mechanically stabilized earthen berms.
3.1.2 Horizontal Expansion
One approach to extend the landfill life is to expand the capacity through expansion. Horizontal and vertical expansions of landfills represent commonplace actions towards achieving additional airspace. According to the April 2018 Bridgeway Acres Landfill (BWA) Annual Remaining Disposal Capacity and Site Life Calculations (CDM Smith), based on the forecasted waste disposal rates, the South Landfill (Class 1) will reach capacity in 2048, with disposal then shifting to the Sod Farm area, which is estimated to reach capacity in 2102. The West Landfill (non-processible waste) is estimated to reach capacity in 2081. Thus, the overall estimated site life of the BWA Class I landfill as reported in April 2018, is 84 years from January 2018.

The BWA landfill is landlocked and there are not any likely options for horizontal expansion. While the discussion of mechanically stabilized walls would yield additional airspace from increased exterior slopes, the overall height of the facility is limited by permitting and zoning conditions due to the proximity of the Saint Petersburg airport.

3.2 Traffic Improvements
The evaluation of the existing campus under Task 5 and discussions with Pinellas County staff and the landfill contract operator (Advanced Disposal) indicate ongoing issues with traffic at the Solid Waste Complex (the “Complex”) on 118th Avenue. Both staff and vendors indicate that the current scalehouse configuration is adequate and transaction traffic is not a limiting factor in traffic flow on site.

The Complex receives waste traffic six days per week, from 6:00 am to 6:00 pm (Monday-Friday) and 7:00 am to 5:00 pm on Saturday. The truck traffic includes residential and commercial route trucks, private haulers, self-unload customers, transfer trailers, and internal traffic using scales for operational tracking (outbound ash, outbound metals, inbound supplies, etc.). The traffic layout was redesigned in 2011 to reduce crossing traffic conflicts to increase site safety. Generally, traffic moves counter-clockwise from the scalehouse to disposal locations and ultimately to weigh out or exit the facility. Disposal locations include the mini hand-unloading area (MINI), yard waste processing area, tire processing area, West Landfill disposal area, South Landfill active face, WTE tip floor and other locations around the WTE facility for inbound and outbound materials (metals, reagents, etc.). There are two pull-out areas for vehicles to remain in the traffic flow but not impede traffic to adjust their vehicles. One area is on the east side of the roundabout and is used for roll off trucks to rotate their cans for return to their customers, whereas the west side location allows for positioning of the containers for dumping if not already properly orientated. These are often compactor cans that require a different container orientation for installation versus dumping the load.

The Complex scalehouse has five inbound scales and two outbound scales. One inbound scale is an automated scale used by commercial route haulers and is located just to the north of the scalehouse and provides quick access for these customers. The remaining four inbound scales rely on interactions with Pinellas County staff for transactions. Similarly, the two outbound scales are for collecting tare weights and completing disposal transactions. There is a bypass road just south of the scalehouse that is used by customer accounts with pre-tared vehicles. The transactions for these vehicles are completed on the inbound side of the operation.
Occasionally, but no less frequent than quarterly, Pinellas County will request that these vehicles weigh on the outbound trip to confirm and re-establish tare weights. The majority of customer traffic goes to either the MINI, landfill active face, or the WTE tip floor.

Review of traffic counts and discussions with staff and customers indicates there are peak time frames just prior to noon and late afternoon. This is typical of solid waste operations and corresponds with “pack out” of route trucks for the morning and afternoon routes. Non route customers are more random but are generally heavier near opening hours (prior to job site operations) or later in the day (post job site operations). County staff indicated that there have been minimal issues with queueing of vehicles into the scale and impacts on 28th Street North.

The primary feature of the onsite traffic pattern is a modified round-about located just downstream from the scales. This feature provides for one way traffic in a counter-clockwise orientation in lieu of a multi-directional roadway to get to disposal areas. All traffic exits the roundabout with a right hand turn and reenters the roundabout with right hand turns allowing all traffic to engage in merging movements and avoiding turns across traffic lanes.

Current operations receive between 1,600 to 1,800 vehicles daily. The Complex managed over 1,200,000 tons in 2017, which equates to approximately 3,800 tons per day. With growth projections from the baseline report, future inbound tonnage at the Complex could be as high as 1,700,000 tons annually or a 40 percent increase in waste received. Applying similar dynamics to the current on-site vehicle traffic yields 2,200 to 2,500 vehicle counts daily.
Figure 3.2 Site features
3.2.1 Strategies for Traffic Management

As the facility grows through increasing waste receipts or expanded operations, on-site traffic management will need to evolve. In managing traffic, the facility has short-term or immediate needs as well as long-term patterns to evolve into.

SHORT TERM

In discussions with county staff and commercial route haulers, no particular time frame was identified for specific traffic interruptions although all did note the daily surges in late mornings and afternoons, typical in waste collection operations. An area of concern was identified at the south end of the roundabout where MINI traffic is returning to the scales and route traffic is heading to the tip floor or trying to exit from the tip floor area. Most MINI traffic must return to the scales to complete their transaction. Most of the route traffic is trying to get to the bypass exit lane just after the container pull-out/management area on the east side of the roundabout. Two proposed solutions include: 1) realignment of the bypass exit road to the east side of the container management area, thus avoiding interaction with the roundabout and 2) developing a separate entry/exit for MINI traffic.

REALIGNED BYPASS LANE

Besides confirming soil conditions and buried utility locations, realignment of the roadway (show in blue in the figure below) should be a conventional construction project requiring the installation of approximately 400 feet of roadway and transitions to the existing roadway. It is assumed this roadway will be the standard 12-foot width and be capable of handling route truck traffic and transfer trailers. The exit radius may need to be modified to handle the turning radius of transfer trailer traffic. Portions of the existing bypass road may need to be demolished to avoid confusion as shown in red below. Roadway costs are forecasted on the order of $50,000 to $100,000. Actual site conditions and pavement design will dictate final costs.
3.2.2 Relocation of MINI Access

The traffic managed by the MINI facility, as the name implies, are hand-unload configurations. These include pickup trucks, box trucks, pull-behind trailers, as well as conventional cars and sport utility vehicles. These vehicles may be operated by experienced contractors or general residents of the county. As there is a likelihood of operators that are inexperienced in an industrial setting such as the Complex, the potential for safety-related incidents is higher. Currently these vehicles share the road with route trucks and transfer trailers. If feasible, it is not uncommon to have facilities servicing these customers separate from general solid waste activities. The location of the MINI was a direct step in keeping these vehicles types separate from the dump zone areas of the Complex, specifically the WTE tip floor or landfill active face which are not appropriate locations for hand-unload operations due to the high volume and throughput these areas require.
Figure 3.4 Relocation of MINI access

This traffic could be managed by charging on a volumetric basis to allow for inbound only transactions or, conceptually, a separate conventional scale(s) and a scalehouse could be installed for inbound and outbound traffic from a designated entrance off 34th St N. Long term, as traffic volumes increase, this traffic would be kept separate from the increasing commercial traffic. Given potential future operations in this location, sufficient area remains north and south of this road to facilitate a transfer station, anaerobic digestion facility or other similar installation. The conceptual roadway is proposed as a two direction, two lane road (inbound and outbound) and would be at least 800 linear feet. If the alignment were to mimic the edge of usable property along the north end, the roadway is estimated to be over 1,000 linear feet. Construction cost for the two-lane road is approximately $100,000 to $150,000. Scalehouse facilities and improvements (scales, canopy, other) are estimated to cost approximately $1.0 million. Actual site conditions, pavement design and scalehouse facility specifics will define final construction costs. The figure and description of an alternative entrance represents one conceptual approach.
as site features and future use considerations may require variations to the alignment and access point to the site.

LONG TERM
Depending on short term improvements, further study may be required to fully understand the complete impacts of traffic in the long term. Types of traffic (route vs. transfer trailer vs. other), operating hours, and other variables will help shape the traffic scenario. Note that as waste volumes grow, the WTE will reach capacity and waste deliveries will either be directed to the landfill or to a transfer station (location TBD) for offsite movement. The roundabout continues to function and is likely to remain a feature in the future. Expansion of this loop to two lanes, simplification of entry/exit points as well as suitability for larger vehicles should all be considered. Should the County pursue movement of MINI traffic away from the current main entrance, a contributing future burden can be offset resulting in minimal additional changes. Due to the increased number of variables, it is recommended that the County continue to review traffic patterns and changes over time after implementation of any short term measures. The available footprint for enhanced facilities and additional traffic routing is limited, so careful consideration is needed when evaluating changes.

Some activities that may improve or impact operations may include offsite consolidation of waste, new disposal facilities (in or out of county), customer service expectations, and scale automation. Another activity that may be considered to further remove MINI style traffic is the development of offsite waste and recycling centers for this traffic. These are small scale facilities for receipt of Class III style waste (C&D, bulky items), recyclables, and HHW. These facilities would require property acquisition, permitting, and development. Examples include Collier County and Miami Dade County. A brief description of the facilities is included below.

Collier County Marco Island Facility: “The Marco Island Recycling Drop-off Center is a 2,897 square foot (SF) one story operations and household hazardous waste (HHW) storage building containing four (4) dumpster/compact exterior bays with retaining wall separations, adjacent concrete maneuvering areas, and separated public and recycling truck lanes for safe operations and efficient traffic flow. The entire site is surrounded by a 6’ high vinyl chain link fence with motorized gates and landscape buffers around its entire perimeter. The site includes an emergency generator, fuel tank, and security cameras. The building has a stucco and masonry wainscot exterior facade with a standing seam metal roof. The exterior windows have storm shutters for required hurricane protection.”

1 www.colliercountyfl.gov
Figure 3.5 Marco Island Recycling Drop-off Center

Completed in 2008, The Marco Island Recycling Drop-off Center is the prototype for Collier County Recycling/Household Hazardous Waste Collection Centers. The Marco Island Recycling Drop-off Center continues to serve residential and commercial customers, providing a convenient location to drop valuable recyclable materials that otherwise would be sent to the landfill. Today, the Marco Island Recycling Drop-off Center accepts a variety of recyclable materials which include household hazardous waste for collection and disposal. In 2010, the Marco Island Recycling Drop-off Center serviced 2,883 local customers and diverted 334 tons of recycled material, decreasing the amount of material entering the Collier County Landfill and preserving valuable landfill airspace.

The pictures below show the North Collier Recycling Drop Off center which included a second floor for personnel offices and training rooms.
Miami Dade: Miami Dade operates 13 trash and recycling centers. With an automated collection system, only refuse that fits into the 96 gallon container is collected. For bulky items, customers may call in for limited curbside pick up (two times per year) or deliver materials to the trash and recycling centers. These facilities also accept small quantities of C&D from residential customers.
Design and construction costs will vary depending on the services provided and complexity of the site. Sites that are limited to customer drop-off facilities with limited ancillary functions but include a scalehouse facility are estimated to cost approximately $2-$4 million. Sites with support buildings as well as additional services (HHW, bulky, yard waste) will require more complex site movements and support personnel and equipment. These facilities will likely cost greater than $4 million but site conditions, level of architectural design, and other features will significantly affect project costs.

Figure 3.8 Miami-Dade County Trash and Recycling Center

Figure 3.9 Collier County NE Recycling Center rendering

Collier County NE Recycling Center Rendering above from Davidson Engineering.2

Collier County’s newest facility, the NE County Recycling Center, opened in the fall of 2018 at a cost of $8.2 million. It includes a 30,000 square foot facility as part of a 14-acre development in a rural portion of the county that lacked sufficient utility infrastructure. Construction included the extension of a water main and some roadway improvements. The facility is a full service HHW and recycling center for residents that also includes administrative space for offices and training.

3.3 WTE Facility Improvements
The WTE facility is currently undergoing significant capital investment to refurbish and extend the operating life expectancy of the facility. The TRP, or Technical Recovery Plan, is a comprehensive program for interior, exterior and pressure part maintenance and replacement of portions of the facility. The program includes upgrades to materials, electrical and pneumatic systems, air pollution control improvements, and emission controls. The facility has already recognized increased efficiencies in boiler availability, steam conversion, and electrical output. Coupled with ongoing maintenance practices, the facility should be positioned for a successful, and additional, multi-decade operational run. Final completion is expected in 2021 although a significant portion of the work is expected to be completed in 2019. Remaining work during the upcoming periods (2020 to 2021) through project completion consists of pressure part projects that can only be completed during a facility outage. The remaining deficiencies identified in the Needs Assessment are not related to the waste processing equipment, but to support operations. These areas include tip floor operations and configuration, and waste storage capacity. Further, an evaluation of processing capacity expansion needs to be performed.

3.3.1 Tip Floor Expansion and Enclosure
The current tip floor is roughly 90 feet wide by 300 feet long, and is totally enclosed. Traffic enters the area via an asphalt apron in front of the enclosed tip floor. Seven 20-foot-wide bay doors line the west face of the tip floor for trucks to back into and dump waste. Each door is only sufficient for one truck at a time. Doors are also located at the north and south end of the tip floor as remnants of previous operating access before bay door installation. The dimensions of the tip floor have been suitable for current operations and should continue to service the facility as the facility reaches operational capacity. Given the exposed west wall due to the bay doors, the area is impacted during weather events; trucks have to maneuver in poor weather conditions, such as rain intrusion onto the tip floor. Further, the ongoing access through bay doors limits the maneuverability of truck for dumping waste and for the management of bulky waste due to limited space for handling these materials. Although not recommended as part of normal operations, short term monitored storage of waste is an advantage of additional tip floor space. Industry recommendations are to keep tip floors free of waste as much as feasible and always when the tip floor is not active and/or not staffed (i.e., outside normal waste receiving hours) as the potential for fires and rapid response is decreased. Recent fires at WTE facilities in Maryland and Virginia, although direct causes vary, had slowed response from detection as the fires were obscured behind large volumes of waste stacked on the tip floor. While this was not the sole cause of the spread of these events, it impeded rapid response.

Expanding the tip floor would increase operational maneuverability for route trucks and tip floor equipment, allow for better receipt of transfer vehicles and other oversized long haul containers, and allow for limited waste staging and processing of bulky waste. Processing in this context
refers to demolition with tip floor equipment, which are typically solid tire wheel loaders. This equipment is capable of size reduction of sofas, furniture, large boxes and even baled waste (typical of materials recovery facility (MRF) residue). The figure below outlines the potential configuration of an expansion of the tip floor. The resulting area is approximately 120 additional feet in depth/width for a total footprint of 300 x 210 feet.

Figure 3.10 WTE tipping floor expansion

Traffic would continue to enter from the current location which would be at the mid-point of the expanded building. The new expansion area would allow for backing and maneuvering similar to the current apron but shielded from weather. The existing bay door wall would require remodeling, but not all bay doors can be eliminated without full scale removal and replacement. An alternative that would allow continued operations during construction is the conversion of the bay doors to two or three bay-wide openings. This would reduce traffic barriers where the western face resides through removal of selected columns. A further structural analysis is required to determine the extent of column elimination allowable. As noted above, full span conversion would require complete demolition and reconstruction of the building and foundations and may not be feasible, while allowing continued operations.

Barring additional structural and architectural details and assuming favorable soil conditions, it is estimated that the cost for this expansion could range between $12 and $15 million. Foundation
conflicts and the extent of modifications to the western wall would require higher construction costs. In addition, to continue operations during construction, night and weekend work for overhead construction would likely be required, further increasing costs. Access control for safety will be needed and techniques such as off hour waste delivery or double handling of waste to bring waste in during non-construction activity hours may be necessary. Although covered in subsequent sections, should the County pursue expanded pit facilities, further expansion of the tip floor may be required to allow either dumping or site equipment access for more efficient use for pit areas beyond the northern and southern limits of the current tip floor. Costs have not been considered for these areas as they are dependent on configuration. Given the scope of the current potential expansion (300’ x 120’) and an expectation that the further additions would be on the order of 120’ x 120’ (in total), additional costs on the order of 40 percent ($4.5 to $6 million) of the previous estimate would not be unrealistic.

3.3.2 Pit Expansion
The refuse pit of the WTE can be considered as the fuel tank for the facility. The ability to store waste and manage pit inventory is essential to efficient operations. The WTE pit for the Pinellas County facility is 240 feet long, 50 feet wide and 35 feet deep (below tip floor elevation). Given HDR’s experience with other similar facilities, HDR estimates the available inventory storage of this configuration is approximately 5,700 tons to the tip floor level. This assumes non-saturated conditions or appreciable standing water at the base of the pit. At peak operating processing capacity this represents just over 1.9 days (46 hours) of storage and is marginally sufficient for operations to cover the period between closing Saturday evening (5 pm) and reopening Monday morning (6 am) or 35 hours. Although many facilities will backstack waste to increase pit storage, the ability to effectively manage backstacking and avoid unmanageable operations from excess waste varies for each plant. In most cases across the industry, three to four days is the recommended minimum storage level. This allows for some flexibility in operations for waste deliveries, including extended holiday closure periods.

The pit is a significant structural feature that is completely comprised of concrete and reinforcing steel with a 3.5 foot thick base and three foot thick walls. The structure is completely below ground making expansion difficult and with commensurately high modification costs. The complexities related to this installation, consisting of excavation, maintaining operations and the final splice into the existing structure will increase overall construction costs. Other considerations include liquids management, maintaining current operations, demolition of the intermediate wall between the expansion and existing pit and expansion of the crane system.

Every ten feet of expanded width at full depth is roughly 250 tons of additional storage. To achieve 24 hours of additional waste capacity (3,000 tons of processing capacity daily at a 5,000 HHV per recent operating history) requires 120 feet of additional pit length. This could be achieved by adding 60 feet to both the north and south of the existing pit, and relocating existing surface features in the proposed expansion area including the control room and motor control center as well as water treatment facilities, all of which would be significant and likely detrimental to this concept. Aerial views of these areas indicate that this may be the upper limit for pit expansion potential. Provisions would be required to continue to allow for crane access and maintenance. Pit expansion through movement of the west wall was not considered, as the
complexity of construction during operations makes this option impractical, as well as creating
significant tip floor building impacts. Construction in this direction would likely require extended
(12 months plus) shutdown of plant operations and is unrealistic given other contractual (PPA
and operating contract) obligations up to and potentially including default of the PPA conditions
resulting in significant revenue loss. In reviewing construction dynamics and the current design,
the approximate capital cost for expanding the pit in the northern and southern directions is on
the order of $9-$13 million. Foundation soil issues, relocation of existing features directly
adjacent to the existing pit, crane replacement/expansion, and construction sequencing will all
have a direct impact on overall cost and may increase costs an additional 50 percent depending
on redesign needs.

An expansion would go beyond the reach of the current cranes, the county would need to
consider tip floor building expansion in the same direction to provide access to the extended pit
for refuse trucks, tip floor equipment and general pit efficiency. Using an additional crane or
relying on current equipment to feed the extra storage space takes away from core chute
feeding operations and may decrease waste processing efficiencies through the addition of
waste handling/movement duties. Recent advancements in automated cranes for off-shift
operations may be an alternative for pit management for these extended reach areas.

3.3.3 Plant Expansion
Waste receipts are anticipated to increase over the planning period. By 2048 there will be
approximately 275,000 tons of additional waste requiring management above the guaranteed
processing capacity. This correlates to about 100,000 tons above peak processing capability at
95 percent availability. From a processing perspective, this represents 300 to 800 tons per day
of processing capacity at 95 percent availability. With any expansion, consideration is needed
for appropriate sizing and phasing, as may be required.

Figure 3.11 Anticipated waste receipts over time
CURRENT FACILITY EXPANSION
The primary challenge to adding capacity at the current facility is available space to accommodate the infrastructure for an additional expansion that was not originally anticipated. Along with pit expansion as discussed previously, space would need to be available to support an adjoining expansion, including the boiler train and air pollution control (APC) systems, as well as the remainder of site utilities and infrastructure that was not developed. Expansion would require a new stack for boiler exhaust, additional reagent storage, modification and expansion of the existing ash handling and storage systems, expansion of the cooling tower bank (possibly redesign and upgrade existing), relocation of existing chemical storage, a new standalone turbine generator (TG) and the associated auxiliary equipment, and new connections to the switchyard or potentially development of an independent switchyard for the new TG as the current switchyard may not be appropriately sized. Limited space is available for the development of a secondary switchyard adjacent to the investor owned utility (IOU) transmission lines. If a new switchyard is required, it will need to be co-located with the facility expansion with transmission to an IOU designated location. The expansion of the existing facility would likely be a onetime event, since further expansion is not feasible or appropriate at this location.

Sizing of an expansion benefits from the availability of the current boilers and presumably sufficient pit volume for operation. At 800 tons per day (tpd), the total facility capacity would be increased to 1,441,750 tons. The guaranteed processing capacity is currently at 75 percent. Under this expanded capacity, this guarantee would be presumably raised to 1,153,400 tons. Sufficient tonnage to meet that demand will be available by approximately 2028, based on current projections.

Table 3.2 Expansion sizing and capacity

<table>
<thead>
<tr>
<th>Expansion size (tpd)</th>
<th>Processing capacity (tons)</th>
<th>Capacity @ 95% availability (tons)</th>
<th>Guaranteed processing capacity (tons)</th>
<th>Year guaranteed tonnage available</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>1,149,750</td>
<td>1,092,260</td>
<td>930,000</td>
<td>current</td>
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<tr>
<td>300</td>
<td>1,259,250</td>
<td>1,196,290</td>
<td>1,007,400</td>
<td>current</td>
</tr>
<tr>
<td>500</td>
<td>1,332,250</td>
<td>1,265,640</td>
<td>1,065,800</td>
<td>2021</td>
</tr>
<tr>
<td>800</td>
<td>1,441,750</td>
<td>1,369,700</td>
<td>1,153,400</td>
<td>2028</td>
</tr>
</tbody>
</table>
Figure 3.12 Pit expansion, boiler train, APC and cooling tower(s) for unit expansion to the north

An expansion to the south was not considered as this would require compete relocation of the existing TG, steam piping and possible modifications to the switch yard.

The space identified in Figure 3.12 above would be sufficient to install a 800-tpd mass burn unit, boiler train and associated air pollution control systems. As identified above some of the existing structures would need to be relocated or expanded to accommodate the new unit. Relocation of these existing features is significant both financially and to the operational coordination that will be required during construction. The existing reagent storage would need to be relocated as part of the tip floor expansion, but new larger silos capable of supplying the entire facility could be constructed at a different location as one of the first projects and tied into the existing facility during a scheduled maintenance shutdown or common outage with minimal impact on the existing facility operations. Similarly, other systems common to the entire facility, such as the ash management and storage/processing systems could be coordinated to minimize impacts to the existing operations. The project with the largest potential impact on the existing operations would be the pit expansion and would need to be coordinated closely with the facility operator. Recent expansions in Lee County and Hillsborough County were successful in implementing new processing lines at existing operating facilities. However, it should be noted that both of these facilities were originally constructed to accommodate such future expansion.

Figure 3.13 provides a conceptual cross section of a proposed 800 tpd mass burn unit. The conceptual design would include a modern state-of-the-art combustion control and air pollution control systems, including the following major items:
In addition, the new facility would include a separate turbine-generator set (not shown Figure 3.13) capable of generating up to 25 MW of electricity to the grid. A newer technology SCR unit would be required for NOx reduction since the Florida Department of Environmental Protection (FDEP) has recently required this technology as part of the new West Palm Beach WTE Facility. A selective catalytic reduction (SCR) system has higher capital and operating costs compared to the standard selective non-catalytic reduction (SNCR) system, but would significantly reduce NOx emissions from the new unit. SCR would likely be required by FDEP.

![Figure 3.13 Cross section of modern mass burn unit](image)

Figure 3.13 Cross section of modern mass burn unit

In HDR's opinion, adding a new 800-tpd unit along the north side of the existing building appears to be technically feasible, but will require additional review of the design options to identify all the engineering challenges and requirements. An expansion of this level would place the plant over the 80 MW threshold for qualified facility (QF) status and is discussed further at the end of Section 3.1.3.3. The type of mass burn grate technology selected for the new 800-tpd unit will also need to be carefully considered. The existing three units use Martin GmbH grate technology and associated controls and if a different unit is selected via a competitive procurement (e.g., Von Roll or Volund), the impact on coordinating the operation of different control systems would need to be considered. Table 3.3 provides the costs of recent WTE expansions and new facility construction at other locations. HDR anticipates the expansion of the existing Pinellas facility would be on the order of recent expansion projects in Florida (in the
range of $225-$275 million), but with additional impacts on costs related to the complexity of construction and coordination with the existing operations.

Table 3.3 Summary of recent WTE projects in North America

<table>
<thead>
<tr>
<th>Facility</th>
<th>Type of Facility</th>
<th>Waste Throughput (TPD)</th>
<th>Electrical Output (MW)</th>
<th>Capital Cost ($M 2017)</th>
<th>O&amp;M Cost per Year ($M)</th>
<th>Capital Cost per TPD ($2017)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Durham York Energy Center, Ontario (2015)¹</td>
<td>New</td>
<td>480</td>
<td>19.4</td>
<td>$262</td>
<td>$14.7</td>
<td>$547,200</td>
</tr>
<tr>
<td>H-POWER, Honolulu²</td>
<td>New</td>
<td>900</td>
<td>33</td>
<td>$370</td>
<td>$56</td>
<td>$412,200</td>
</tr>
<tr>
<td>Palm Beach Renewable Energy Facility 2, West Palm Beach, FL (2015)³</td>
<td>New</td>
<td>3,000</td>
<td>95</td>
<td>$712</td>
<td></td>
<td>$237,000</td>
</tr>
<tr>
<td>Lee County Waste to Energy Facility, FL</td>
<td>Expansion</td>
<td>636</td>
<td>20</td>
<td>$165</td>
<td></td>
<td>$260,000</td>
</tr>
<tr>
<td>Hillsborough</td>
<td>Expansion</td>
<td>600</td>
<td>17</td>
<td>$170</td>
<td></td>
<td>$283,000</td>
</tr>
<tr>
<td>Olmsted Waste-to-Energy Facility, Rochester, MN</td>
<td>Expansion</td>
<td>200</td>
<td>6</td>
<td>$101</td>
<td></td>
<td>$507,000</td>
</tr>
<tr>
<td>Covanta Dublin, Ireland (2017)⁴</td>
<td>New</td>
<td>1,800</td>
<td>58</td>
<td>$650</td>
<td></td>
<td>$357,500</td>
</tr>
</tbody>
</table>

Notes:
All tonnage shown in U.S. tons; dollars are in U.S. dollars; TPD = tons per day
1. https://www.durhamyorkwaste.ca/FAQ/FAQ.aspx#cost
3. www.swa.org/375/Palm-Beach-Renewable-Energy-Facility-
4. Covanta Q4 2016 Earnings Call Final Transcript, Page 11

### 3.3.4 Standalone processing at the current site

Although lacking economies of scale, an additional option would be the development of a standalone facility that is completely independent of the existing facility, with the potential exception of electrical connections to the switchyard. This approach was used recently to expand capacity on existing sites at the Honolulu WTE facility (or “H-Power”) and the Palm Beach County WTE facility. Space is limited at the existing Pinellas site and a “greenfield” development would require relocation of existing features at the Complex, or extensive transmission line installation, should the existing switchyard be the only point of connection. Long transmission lines would be part of an installation that were either located on the property immediately west of the Solid Waste administrative offices or located in an area designated for future landfill across 28th Street North, in the “Sod Farm” future landfill expansion area. Land requirements for this facility would be on the order of 10-15 acres, depending on its final design configuration and whether additional facilities such as scalehouses would be needed.

Figure 3.14 below depicts three potential locations that have satisfactory area for the development of a standalone facility.
Figure 3.14 Potential areas for standalone facility

Each presents separate challenges, as they will consume space that is either reserved for future landfill use or requires relocation of existing operations. For example, the area to the north occupies the remaining undeveloped land at the Complex. This area has also been proposed for additional future facilities under this report such as, but not limited to, a transfer station for offsite waste movement, a facility for bulky waste processing, alternative entrance facility for MINI customers and potential location of an anaerobic digester (AD) facility for management of food residuals and other organics. On site transmission lines would be needed to deliver generated power to the current switch yard connection to the electrical grid. The space available is roughly 10-12 acres and could support a plant equivalent in size to the existing WTE facility.

The area to the east is located in the footprint of proposed future landfill expansion. Although space is readily available, this location would affect the long term capacity of the Complex for disposal. This location would either require underground transmission to the existing switchyard interconnection point (if allowed) or a new connection to the electrical grid and associated interconnection agreement with the IOU (Duke Energy). Expansion capabilities in this location would be less restricted and a WTE comparable to the existing Pinellas facility, or larger, could ultimately be constructed over time.

The third potential development area takes advantage of the proximity to the existing switchyard and connection to the electrical grid. This area represents the smallest of the three potential spaces, at approximately eight acres, and would only support a smaller, one or two unit, installation. Configuration for waste deliveries may need to be modified to avoid the necessary road configurations and tip floor space needed to support the facility. Using the side slopes of the landfill could be examined to account for some of the access restrictions. This location also includes several key site operations including: visitors center, HEC₃ facility, and landfill site
operations and maintenance. All these would need to be relocated on site and/or offsite (with another disadvantage to this option that all of these facilities are relatively new).

The processing unit layout of the standalone option would be arranged similarly to the proposed 800-tpd mass burn unit addition at the current facility location (see Figure 3.14 above). Dedicated storage silos for reagents and chemicals would also be required, as well as a dedicated building for the new approximately 25 MW TG. The standalone facility would require dedicated access roads and a tip floor. New waste handling cranes could be advantageous assuming there is sufficient area available to construct an oversized storage pit that can service both facilities without having to expand the pit at the current site. This would require the ability to transfer waste between facilities, but that can be accomplished by designing the stand-alone plant with a transfer and loadout area. Given the proximity of the potential development areas to the current facility, a dedicated ash treatment and management building would be required. Another potential advantage of this standalone option is it could provide the County better flexibility in a competitive procurement for selecting a mass burn technology different from the current operation, since there would not be a need for shared or common control systems. Additional cooling tower cells could also be added to the existing facility cells as shown on Figure 3.14. One of the biggest advantages of this standalone option compared to developing an 800-tpd unit at the current facility is that the construction and startup will have minimal impact on the existing operation. A potential challenge (or disadvantage) of a separate standalone facility would be the need to have a separate crew to operate the facility, which could result in higher operating costs.

Table 3.2 above identifies the costs of recent projects that implemented standalone expansions on an existing adjacent site, including the H-Power facility in Hawaii. Based on these projects and our recent experience, HDR anticipates that the probable costs for the standalone facility option for Pinellas County would be on the order of $250-$300 million.

With any standalone expansion or expansion, the county runs the risk of losing qualified facility (or “QF”) status. This is a limitation offered to facilities that are less than 80 MW gross generating capacity. As a QF, the County is able to dump any electrical generation into the grid and be paid the as-available pricing by the IOU within that service area, which in Pinellas County’s case is Duke Energy. Alternately, as a non-QF, the County will need to secure power purchase agreements (PPAs), standard offer agreements with Duke Energy and other utilities that could be potentially used when transmission service is available to wheel power. When transmission is not available or when the IOU’s are not seeking power, power will not be able to be sold. Distributed heat loads or use of cogeneration electrical generating units are outside of this classification and are allowed without risking losing QF status although consultation with a local power market specialist is recommended should the County pursue such technology.

### 3.3.5 Waste Storage

Waste deliveries to the Complex can be anticipated, but are not entirely predictable. There are naturally occurring variances and surges depending on the time of year, time of day and changes in the local economy. The concept of waste storage is to provide additional capacity such that this capacity can be fed to the facility when deliveries are down. At full (92 percent)
operating capacity, the facility can process 1,000,000 tons of waste per year, or just under 3,000 tons daily. The remaining 8 percent of non-availability is due to scheduled outages and unscheduled maintenance events. There are scheduled outages annually per unit, typically lasting approximately 11 days for a major and four days for a minor. The minor outages are for cleaning and are rotated at one event per unit per month except during major outages. This totals 3 events per unit or 12 days per unit. All outages total 69 unit downtime days, or 6 percent of available operating boiler unit days. The total days available for three units is 1,095 days. The remaining 2 percent is occupied by unscheduled outages for up to 22 days annually, or just over one-half day per unit per month. Operating conditions may vary and this breakdown is presented to assist in quantifying the waste storage conditions. Should long term operational throughput vary, the results would be adjusted accordingly.

Revisiting the information presented in Task 5, there is about an 8 percent difference in waste deliveries during March through September vs. the remaining months. Using an average 30-day month, the facility should process nearly 95,000 tons. Current information shows that the facility has limited periods where it is operating at full capacity, although the completion of the TRP will assist with this availability. It is also known that sufficient waste exists to reach capacity, but that it may not be delivered when that capacity is available. Using the above as an example, if during the months between March and September the facility was performing at full capacity, there would be roughly 8,000 tons per month of additional capacity available in the “off months” for a total of almost 40,000 tons.

Two practical solutions have been identified for the county: storage within the landfill airspace for future retrieval, or encapsulated storage. The county is familiar with on-site landfill storage and the complications that are associated with this methodology. Excavation, transport, potential for odors, and partial decomposition of waste placed in the landfill are all hindrances. Further, waste in the landfill may be subjected to weather events causing increased moisture
content. Lastly, cover soils need to be removed, and if they remain, may present a corrosion/erosion impact on the facility’s boiler train.

Although used mostly for long haul transport of waste, there are examples of waste encapsulation in the U.S. (see Figure 3.17). Most of the technology and equipment was developed in Europe as an alternative to conventional baling. Waste is compacted into square or cylindrical bales and wrapped in linear low density poly-ethylene (LLDPE) plastic. Most of the wrapping has a useful life of under twelve months when exposed to the environment, so burial or protection of the bales is required for extended storage. Information provided by the manufacturer shows that waste materials in the bales, due to the excessive compaction, have little opportunity for decomposition due to the inability for moisture or air to move within the mass. Studies also show no appreciable increased temperatures during storage.  

Figure 3.16 EuRec round baling system (RBS-2)

An example of the equipment utilized in these operations is shown above. The unit includes a charging hopper, conveyor and baling system. Although the waste typically requires no preprocessing, several manufacturers offer shredding and ferrous recovery systems prior to feeding the system hopper. The systems are capable of being operated by one person, although feeding the system and removal of the bales requires additional staffing. Specialty bale grabbing equipment is available, as well, that can be adapted to Lull style, extended boom forklift equipment for movement of bales.

Equipment cost is on the order of $1.2 to $2 million depending on configuration and components (shredders, ferrous removal, dosing feeders). Operational costs are on the order of 2-3 percent of capital cost annually (per the manufacturer’s specifications) which would be approximately $200,000 to $600,000 annually. Wrapping for the bales is approximately $6 per bale. Bale weight can range from 1.5 tons to just over two tons per bale. Given the example above for

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3 Expert’s report of University Rostock regarding EuRec-Round Baling System RBS-2, October 2005
demonstration purposes, at 40,000 tons per year, the wrapping cost would be approximately $240,000 per year. Operational cost for 40,000 tons is about $11 to $21 per ton of stored waste, not including capital amortization or power costs. Power demand is 20 to 70 kWh depending on configuration and equipment. Labor and other support equipment would add another $5-10 per ton.

Figure 3.17 Baling operation Haverhill, Massachusetts

3.3.6 Reducing In-house Power

As described in Task 5, the WTE exports net electrical energy to the local grid for sale to Duke Energy. Approximately 10-15 percent of the facility’s generation is consumed on site (known as “parasitic load”). These are electricity consumption needs for facility start-up and operation. All general site utilities for landfill and administrative functions and the industrial water treatment facility (IWTF) are supplied from the local electrical utility. Providing in-house power to these services onsite would reduce site operational costs while also decreasing net available energy to the grid. Under the county’s power purchase agreement with Duke Energy, the county is limited to nameplate gross power, or 75 MW, for distribution. As the facility is at or under 80 MW, it is designated as a QF under the Public Utilities Regulatory Policies Act (PURPA). Under this legislation, the County receives revenue from any electrical energy not covered under a purchase agreement at the connected IOU’s (i.e., Duke Energy’s) avoided cost rate, for available energy. In Florida, this avoided cost is indexed to natural gas and yields relatively low rates for the marketplace. The county’s facility is located in the Duke Energy service area and absent any scheduled transmission to other IOUs, Duke Energy would be the default IOU for energy sales under PURPA.
HDR views two primary strategies available to the county to supplement power generation, and reducing the effects of parasitic loading: landfill gas-to-energy (LFGTE) and solar power. Both technologies are also considered renewable energy, and the county has available site features that would allow it to benefit from either, or both, of these strategies. In theory, any generating capacity developed on site would be limited to offsetting, up to but not exceeding, the nameplate generating capacity of the WTE such that the resultant energy is still net of generating capacity. Currently, landfill gas (LFG) generation is not capable of economically supporting a LFG to energy facility but may be capable as LFG generation increases over time.

The PPA defines net electrical energy as “all electric energy generated by the Facility in excess of the electric energy used by the Facility for Facility operations” where the facility is defined as the Resource Recovery Facility. The agreement further states in the preamble that “the County proposes to make available and to sell approximately sixty megawatts (60 MW) of net electric capacity”. While supplementing parasitic load by supplying power to the plant via external onsite sources would increase the net electrical output beyond 60 MW, and up to potentially 75MW, the agreement does not appear to constrain the facility to only the sale of 60 MW. HDR recommends consultation with the County Attorney regarding the intent of this preamble, and to obtain a legal opinion on the effect of the preamble language on the enforceability of this agreement. Further, consultation with local market power specialist is advised in developing a “station power” strategy, where station power is activity that occurs before metering.

LANDFILL GAS TO ENERGY

The Bridgeway Acres Landfill is not required to collect LFG under current regulations. The facility continues to be tested for non-methane organic compounds under Tier II protocols of the New Source Performance Standards (NSPS) and has not exceeded regulatory limits, nor will it in the foreseeable future based on recent testing, unless MSW receipts to the landfill increase year over year. Using information from the recent (CDM 2017) testing report, HDR estimates that landfill gas generation across the waste mass is approximately 1,478 cubic feet per minute (cfm). Although a portion of the samples were dispersed across the whole site (approximately 260 acres) the majority of samples were taken on the more active portion of the site, representing approximately 122 acres (see Figure 3.18), although about 86 of these 122 acres are more likely of being less disturbed under current operations, and thus more suitable for LFG system installation. At 1,478 cfm, assuming the majority of gas is being generated in the active landfill area, a LFG collection system at 75 percent collection efficiency is estimated to generate just over 1,100 cfm.

As the landfill contains MSW co-disposed with WTE ash, further investigation must be performed as to whether these gas volumes are actually present and recoverable. Although the landfill operations encourage MSW to MSW contact to avoid discrete lenses of waste, the excess amounts of ash available make it unlikely the waste in the landfill is contiguous. Conversely, the absence of discrete lenses of MSW can be expected to cause extraction of LFG to be restricted. Further, any encapsulation of waste will hinder the generation estimates from lack of free gas flow, cause suboptimal moisture conditions, cause unfavorable pH values, and create the inability for transport of gas generating microbes throughout the waste mass.
The following provides an overview of alternative uses for the collected LFG. This overview of LFGTE technologies can assist the county in understanding alternative or supplemental options.

**MEDIUM-BTU GAS**

This option involves direct thermal utilization of the LFG as a medium-BTU fuel by piping the LFG to a nearby thermal energy-user (to offset natural gas or other fossil fuel usage). As the WTE facility uses natural gas for supplemental fuel, a medium BTU application may have value on site but would potentially require the development of gas compression and storage facilities, require LFG conditioning, and may require modifications to WTE burner tips, depending on percentage of flow from the LFG system. Further, any blending would need to occur downstream of the natural gas meter and include restriction for backflow into the natural gas piping network. Demand for the LFG would be limited to supplemental use times and sufficient flows would be needed during those periods. As LFG flow would not be regular, financial return on this option may not be favorable.

**ELECTRICITY GENERATION**

Producing electricity from LFG is the most common LFGTE application in the U.S., accounting for about three-fourths of all U.S. LFGTE projects. Electricity can be produced by using LFG as a fuel source in either an internal combustion engine, a gas turbine, or in microturbines. In Pinellas County’s case, LFG-generated electricity could be introduced to the grid through the existing switchyard. As the County is currently operating under a PPA with Duke Energy, revenues through 2024 would be initially projected, taking into consideration these electrical
energy sales values. After 2024, as with the WTE facility, all electrical energy sales will be subject to spot and as-available pricing markets, absent a renewed or new PPA.

Renewable Energy Credits (RECs) and other similar Florida state-specific incentive programs are additional sources of potential revenue from sales of electricity generated by LFG and WTE. Given the current market environment and generally low value of RECs, it is currently recommended to carefully evaluate availability of future revenue from RECs in exploring the financial viability of LFGTE projects.

Specific to the landfill, the “LFG available for alternative use” could support two primary electricity generation technologies: Engine generators, and turbines.

ENGINE GENERATORS

Electricity generation can be achieved by means of reciprocating engine generators. These may require minor pretreatment processes (depending on LFG quality) and specific operation and maintenance (O&M) procedures to address the contaminants commonly found in LFG. Control systems, switchgear, and a step-up transformer are also required to increase generated voltage and maintain synchronization to the local electric transmission lines. Depending on the growth of a landfill, LFG-fueled engine generators are usually installed in increments, as additional units are installed to take advantage of increasing quantities of LFG available. There can also be situations in which more LFG is being collected than can be utilized by the generators installed (in which case the excess LFG would be flared).

At estimated LFG generation rates, which are anticipated to neither increase nor decline due to limited waste disposal, the landfill could support up to three generator sets (genset) units (CAT 3516 at 325 cfm per unit) with a total potential generating output of approximately 2.25 MW.

Major costs associated with engine-based LFGTE projects are identified below:

- **Capital Cost:** Capital costs are dependent upon equipment selection, pretreatment requirements, and interconnection with the purchasing entity. Based upon the LFG lab analysis results to be provided by County staff, pretreatment of the LFG will likely be required for the engine generator option at the landfill. It is important to note that each manufacturer typically performs their own analysis of feed gas prior to providing a warranty for their installations.

- **Operations and Maintenance (O&M) Cost:** Routine maintenance on the engine generators such as oil changes, filter replacements, and general tuning are important to continue to maximize electricity output and revenue. These costs are usually modeled on a $/kWh basis.

- **Overhaul Cost:** Every 40,000-45,000 operational hours (approximately every 5 years), the engines require a complete overhaul, restoring the engines to like-new condition. This is usually modeled as an amortized cost.

At 1,100 standard cubic foot (scf) (75 percent collection efficiency) the potential revenue generated, assuming 92 percent uptime, is approximately $470,000 per year under the current PPA pricing (2018) per the County’s agreement with Duke Energy. This reflects all energy sales and assumes no capacity adjustments. Installation costs for 86 acres of LFG collection and a
flare station are estimated to be approximately $2 to $3 million. Genset facility and installation costs are estimated at around $4 to $6 million depending on equipment features and LFG clean up processes needed for facility operation. Annual operations and maintenance for this type of system range from approximately $50,000-70,000 annually for the collection system and $200,000 to $300,000 per year for the generating facility and equipment.

TURBINES
Gas turbines are a technology option typically utilized in LFGTE projects in which LFG flow rates exceed approximately 1,600 standard cubic feet per minute (scfm) of available gas which exceeds current estimates for generation and is not viable for the county’s purposes, but is provided here for reference only. This is due primarily to the economies of scale available for this technology. The cost per kW of generating capacity drops as the size of the gas turbine increases, and the electric generation efficiency generally improves as well. However, the economics, and the physical conversion efficiency of gas turbines drop substantially when running at partial load. Advantages of gas turbines are that they are more resistant to some forms of corrosion damage than internal combustion engines and have lower nitrogen oxides (NOx) emission rates. Additionally, gas turbines are relatively compact and have relatively low O&M costs as compared with internal combustion engines. However, gas turbines have strict requirements on Siloxane thresholds, and pretreatment costs may be even higher compared to the engine generator technology discussed above.

Similar to engines, control systems, switchgear, and step-up transformers are also required to increase generated voltage and maintain synchronization to the local electric transmission lines. Depending on the growth of a landfill, gas turbines can be installed in increments, as additional units are installed to take advantage of higher quantities of LFG available. However, since the turbine has a larger capacity than the engine, the incremental capacity additions will be larger for the turbine. This may require that some LFG is directed to a flare until sufficient flow is available to justify the additional units.

Many turbine manufacturers provide excellent products for LFGTE use. One such example is Solar Turbines, specifically the Mercury 50 unit with 4,707 kW rated output. This unit has a lower heating value fuel inlet requirement of 42,400,000 BTU/hr. Calculating parasitic loading, percent availability, and contingency for dips in methane content of the LFG, the Mercury 50 requires approximately 1,550 scfm of LFG (with 50 percent methane and 455 BTU/scfm net heating value) for full utilization. As the Complex is not anticipated to generate LFG at this level, this technology is not appropriate until such time that LFG generation increases. Major costs associated with turbine-based LFGTE projects are identified below:

- **Capital Cost**: Capital costs are dependent upon equipment selection, pretreatment requirements and interconnection with purchasing entity. Pretreatment of the LFG is generally required for a turbine option at the landfill. It is important to note that each manufacturer typically performs their own analysis of feed gas prior to providing a warranty for their installations.
- **O&M Cost**: Routine maintenance on the turbines is important to continue to maximize electricity output and revenue. However, O&M costs are relatively lower compared to engine generator technology. These costs are usually modeled on a $/kWh basis.
• Overhaul Cost: Similar to engine generators, turbines will require overhaul per manufacturer recommendations. This is usually modeled as an amortized cost.

HIGH-BTU GAS
LFG can also be processed to the equivalent of pipeline-quality high-BTU gas (RNG), compressed natural gas (CNG), or liquefied natural gas (LNG). Pipeline-quality gas can be injected into a nearby natural gas pipeline and the energy and/or environmental attributes sold to the local utility or other buyer(s) at other locations. If the energy is sold to the utility and the environmental attributes are retained, these can be sold once the equivalent RNG is converted into CNG or LNG. CNG and/or LNG can be used on-site to fuel vehicles at the landfill, fuel refuse-hauling trucks, and possibly supply the general commercial market, or delivered to a remote location by displacement on the natural gas pipeline system. The following are the typical processes that are commercially employed in the United States: water scrubbing; amine scrubbing; molecular sieve; and membrane separation. In general, these high-BTU processes can result in product gas with an equivalent heating value to natural gas. This RNG product gas is commonly utilized (sold) by either direct injection into a nearby natural gas pipeline, or further processing (compression) to produce alternative transportation fuels such as compressed natural gas (CNG). Although technically viable, the quantities of LFG at the facility are not sufficient to financially sustain this type of application at this time.

ON-SITE CNG PRODUCTION
The following is a listing of applicable details relating to potential on-site production of CNG for fuel use:

• It is important to note that the on-site CNG technology option is highly dependent upon the available “market” or end-users that would purchase the product CNG. Specific to the county, approximately 1,100 scfm of the total LFG available would be able to generate over 2,000 gasoline gallon equivalents (GGEs) of CNG per day. This is a large amount of GGEs for a fleet to consume daily and may require acquiring other customers such as waste haulers (public and private) as well as onsite landfill operations.
• The unknowns in determining feasibility of this technology include the availability of public or private fleets that are or could be retrofitted to CNG and whether agreements could be developed for sale of the final product.
• BioCNG and Xebec Adsorption USA, Inc. are vendors providing CNG conversion technologies. Unlike electricity generation and pipeline high-BTU projects, the costs for constructing and operating a CNG processing plant do not end with the production of the CNG product gas. The economics of this option also require customer capital investment to retrofit existing gasoline/diesel fueled fleet vehicles to CNG-fueled vehicles and/or purchase of new CNG vehicles which will affect the retail rate they are willing to accept for fuel purchase.

SOLAR PANELS
One potential opportunity to increase electricity for onsite use or sale to the grid includes generating electricity from solar panels. The quantity of electricity will depend on the size of solar array installed. Determining the potential value of such an undertaking will entail assessing:
• the potential size of the project,
• proximity/access to an end-user, on site demand or the grid system,
• proximity to the public and screening from public view,
• operation and maintenance costs for the facility,
• corrective action requirements (if any) that would be required for solar work to be completed,
• grid interconnection location and capacity availability,
• metering structure,
• fire safety evaluation,
• typical equipment and identification of specific technical requirements to meet health, safety or regulatory requirements,
• PV production analysis for life cycle cost comparison, and
• permit conditions and/or limitations both locally and regionally.

Prior investigations by the county regarding utilization of the closed Toytown landfill identified installation of a solar farm at that location as a potential option. The county has had conversations with Duke Energy regarding several different solar concepts without success. With restrictions regarding the QF status of the facility, significant solar investment without IOU participation is challenging although generating capacity up to nameplate generation to displace onsite loads is technically feasible but would require further consultation with power market specialists. Other strategies such as utilization of closed landfill slopes or floating arrays on site ponds would all require additional analysis as to viability and economics.

3.4 Use of the Closed Toytown Landfill
As noted above, Pinellas County has evaluated potential development options at the Toytown Landfill, including issuing a request for negotiation issued in 2015 by the County’s Economic Development Department to develop the site. The lack of historical and operational records for this landfill, closed in 1983, complicates the ability of potential developers to confirm what they may find. In 2018, the county had SCS Engineers conduct a limited historical document review, subsurface exploration, and waste volume estimate. The study included an assessment of potential considerations for redevelopment. Potential development options previously considered included use as a solar farm discussed above and the possibility of removing the existing waste (SCS estimated ~10.8 million CY or ~7.6 million tons) prior to redevelopment (which would help eliminate the settlement concerns related to development over existing waste deposits). That approach would entail confirmation of the environmental and economic viability of removing, transporting, processing, and disposing of the removed materials, potentially at the Complex. Another option identified in the SCS report was the potential to use direct dynamic compaction, if building foundations are part of the development. Ultimate disposition of the Toytown site will depend upon the option selected and how the potential issues of waste content and settlement are addressed, which may require additional studies.

3.5 Ash Processing/Metals Recovery
The two primary aims related to the recycling of ash are recovery of saleable ferrous and non-ferrous metals and production of mineral aggregate products that can be beneficially used for
applications such as construction aggregate and cement kiln feed. Through the recovery of metals, potentially high-value commodities can be realized, but this represents a relatively small fraction of the MSW. The recovery of mineral products, on the other hand, provides the potential for the diversion of large amounts of ash from landfill disposal. As described in the earlier Needs Assessment Report, both recovery opportunities exist, but a major decision that must be addressed is which ash stream will be targeted: bottom ash or combined ash. Here we examine the advantages and disadvantages of each approach.

3.5.1 Ash Characteristics
At the facility, as is the case at most WTE facilities in Florida and the U.S., fly ash and bottom ash are combined within the “four walls” of the WTE facility to create a “combined ash” stream. This practice is unique in comparison to other parts of the world where ash recycling is commonly practiced. At most U.S. WTE facilities, fly ash is either discharged directly onto the bottom ash conveyor or conditioned and mixed with bottom ash at a final staging point within the facility. Fly and bottom ash are primarily combined to avoid the potential for the classification of the fly ash as a toxicity characteristic (TC) hazardous waste under the Resource Conservation and Recovery Act (RCRA). Hazardous wastes are subject to more stringent and costly management and disposal regulations compared to wastes classified as non-hazardous. The mechanism through which wastes are designated a TC hazardous waste is the Toxicity Characteristic Leaching Procedure (TCLP). The TCLP is a laboratory test where waste samples are introduced into an acetic acid-based solution, and the concentrations of specific metals and organic contaminants released (leached) into that solution are measured after a fixed extraction time. TCLP results are compared to established TC hazardous waste thresholds (numeric concentration limits) to determine if the waste is classified as hazardous. By mixing the fly and bottom ash to form combined ash, facility operators can best ensure that no part of their ash stream is hazardous waste.

Bottom ash consists primarily of the MSW components remaining on the grate system after the waste has passed through the boiler. The primary components of bottom ash are incombustible waste components such as glass, concrete, brick, porcelain, soil, and metal. Upon examination, some bottom ash particles are recognizable as distinct pieces of concrete, brick, glass, or metal. Other particles, referred to here as slag, result from components melting in the combustion zone and cooling; some slag particles are glassy in appearance while others exhibit a high metal content. Depending on the combustion efficiency of the facility, unburned organic materials may also remain in the bottom ash. Smaller combustion residual particles, typically with a black or grayish color, coat much of the larger particles. In addition to the materials passing over the grates and through the boiler, bottom ash may also contain other WTE facility residual streams, including small materials falling through the grates and ash collected in devices such as the economizer or superheater.

While bottom ash contains larger pieces of material similar in size to construction aggregates (hence the common objective of recycling bottom ash in place of natural construction aggregates), fly ash consists of much finer particles. As air travels through the combustion zone of a WTE facility (necessary for the combustion reaction), it carries with it fine inorganic particulate matter resulting from the combustion process. As the resulting post-combustion gas
(primarily a mixture of nitrogen, carbon dioxide, oxygen, and water vapor) passes through the WTE ductwork and into the air pollution control system, these fine particles are removed, primarily using a series of baghouses. The particulate matter is routinely removed from the baghouse filters and then conveyed along with the residues formed by the acid gas scrubber as fly ash. Fly ash particles, in addition to being much smaller than bottom ash particles, are more enriched in some heavy metals, and although both bottom and fly ash have a high pH (pH > 10), fly ash pH tends to be greater, especially when excess lime is used in the air pollution control system.

Fly ash is very dusty and is thus typically conditioned by mixing with water. Within the facility, the two ash streams are at some point blended to form combined ash. Most WTE facility operators perform metals recovery within the facility, almost certainly for ferrous metal, and very commonly for non-ferrous metal. The point in the ash conveyance system at which magnets and eddy current separators are located varies from facility to facility. The waste to energy industry recognizes that small ash particles, particularly those in fly ash (these are often “sticky”), act to reduce screening efficiency and ferrous/non-ferrous metal removal efficiency, especially for smaller metal pieces. A substantial amount of recoverable metal content remains in the ash at most facilities, particularly those where the electromagnetic separation systems are applied to a combined ash stream. The opportunities for recovering and recycling ferrous and non-ferrous metals from ash discussed below, target recovery after conventional metals recovery, typically occurring within the WTE facility.

### 3.5.2 Processing and Recycling Opportunities

The two recycling opportunities identified above, metals recovery and mineral product production, require that the ash be processed prior to use, regardless of whether the feed material is combined ash or bottom ash. Ash processing operations occur throughout the world, particularly in Europe, but also in Asia and North America. Outside of North America, these facilities target bottom ash, as the regulations require or otherwise promote the separation of bottom ash from fly ash. In some cases, the only target of such processing operations is the recovery of metals, while in other cases the metals extraction is accompanied by the production of mineral products for recycling. In North America, operational facilities are more likely to target combined ash, and while mineral products represent a longer-term objective (continued research is underway on this option), metals recovery is the driver behind the operation. The remaining mineral ash is landfilled.

Ash processing operations are typically located either at or near the WTE facility or the landfill receiving the ash. Most often they are operated by third-party contractors. Several different companies, most of them originating in Europe, now market ash recycling process trains around the world. Some of the vendors market patented processes as part of their operation, but by large, the facilities share a common approach. Ash is processed through a series of conveyors and screens to create distinct particle size fractions, and each of these fractions is then subjected to eddy current separators (ECS) to pull out non-ferrous metals (magnets will be located throughout the operation, but the primary revenue source, and thus the focus of the operation, is the recovery of non-ferrous metals). In addition to some proprietary equipment employed to make metals recovery more efficient, factors that set equipment vendors apart
include operational experience with different types of ash, the ability to market the metals recovered from the ash, and the ability to develop and foster markets for the mineral products.

For Pinellas County, the most likely route for developing an ash recycling operation will be to enter into an agreement with a third-party contractor (which could possibly be Covanta, the current operator of the facility). This facility, whether processing bottom ash or combined ash, should be expected to involve the following:

- A contract will be established between the vendor and the county that sets forth a fee for processing or procuring the ash and a formula for sharing in any revenue from the sale of metals. If the marketing and reuse of mineral products is to occur, this could happen as part of the contract or it could be an effort managed by the county (or other party).
- Establish a dedicated processing facility or area. Such an operation will either require permitting as a new waste processing facility or will need to be integrated into the facility’s overall operations permit. Appropriate changes to the facility’s currently permitted ash management plan will be required. The facility could either be located inside of a building or out of doors; any leachate generated by the ash will be required to be properly controlled (several operations in North America are located on top of existing permitted ash landfills with leachate control).
- The ash streams created will need to be characterized to determine whether any products (unless otherwise excluded) or residual materials stream are hazardous waste or not.
- A staging area for stockpiling and curing raw ash will be required. Most ash processing operations in North America do not process ash directly after transport from the WTE facility. The ash is often wet and sticky, and several weeks of curing is often needed so the ash can effectively be processed.
- The facility will require heavy equipment to move most the materials around the site, including breaking up stockpiled ash and loading it into the process train, removal of product streams to appropriate storage areas, and transfer of remaining residuals to the landfill.
- This facility will include a processing line consisting of multiple conveyors, screens, magnets, ECS, and storage bunkers.
- Product storage areas will be required. If mineral products are created, additional curing time may be required to meet environmental reuse requirements.
- Several different processing models will likely be offered by vendors. In one model, a fixed facility is constructed as a permanent or near-permanent facility to be operated year-round. In another model, mobile processing equipment will be transported to the facility for several months at a time to process stockpiled ash.
- Product vendors will typically be experienced with marketing recovered metals. The amount of revenue returned to the county from the sale of metals will depend on the negotiated conditions of the contract.
- The marketing of mineral products as construction products (road base, concrete/hot mix asphalt [HMA] aggregate) will first require permission from the FDEP, and will require an extensive up-front analytical testing effort.
All of the issues discussed will be applicable regardless of whether the ash source is combined ash or bottom ash. The next two sections focus on some of the differences that might occur as a result of processing either combined ash or bottom ash. The discussion is organized by the two major recycling objectives: recovery of metals and production of mineral products.

**COMBINED ASH VS. BOTTOM ASH: METALS RECOVERY**

As described above, multiple vendors currently market services for constructing and operating ash processing operations for advanced metals recovery (AMR). Many of these companies developed their technologies in Europe and they now market in North America. Even though the target feed stream in Europe is bottom ash (fly ash is managed separately), they have adapted and applied their technologies for combined ash streams in North America. AMR facilities are currently in operation in several U.S. states. One vendor operates a mobile operation in Florida and has processed combined ash both in Broward County and Hillsborough County. Pinellas County should expect that vendors will offer services for ash processing and AMR services whether the feed stream is combined ash or bottom ash. The vendors have extensive experience with bottom ash from Europe, and limited (but real) experience on processing combined ash in the U.S. From an AMR perspective, Pinellas County should expect several distinct differences with respect to the decision to target bottom ash or combined ash.

- Processing and recovery of metals from the bottom ash is simply easier to accomplish than from combined ash. Combined ash contains more fine materials that are sticky in nature. This tends to create more equipment maintenance and downtime. The overall efficiency of the operation (tons of metal recovered per ton of ash processed) will be lower. This is because the metal-rich bottom ash is now diluted by the fly ash, and the metals recovery efficiency is lower because of the fly ash. Size fractionation of the ash allows for significantly increased yields in metals recovery using ferrous extraction technologies such as magnets and dynamic ferrous separators, and non-ferrous metal removal using ECS. Performance of this equipment is significantly increased when the material is homogenous in particle size and the metal is free from other particles. Some vendors will offer proprietary equipment and specialized experience to better solve these issues. The county should expect that the processing costs and share of metal sales will be less for combined ash relative to bottom ash.
- Additional stockpile area and time may be needed for combined ash storage. One of the challenges with processing combined ash is that it cannot be fed directly to the processing equipment; time is needed for the ash to dry and become easier to move through the processing system. During this storage time, the ash often hardens and thus must be broken up before fed into the processing line.
- When the bottom ash is separated from the fly ash, the remaining fly ash must be tested to make sure it is not a hazardous waste. This is especially important if the AMR processing occurs outside the “four walls” of the facility as interpreted by FDEP. To address this concern, some facilities blend a portion of the bottom ash back with the fly ash, thus creating a waste stream that can still be disposed of as a non-hazardous solid waste. If combined ash were processed, it is unlikely that TC status would change.
- While AMR on bottom ash should result in a less expensive ash processing operation to the County (in terms of $/ton of ash processed), the County would incur an internal expense to reconfigure the WTE facility to separate bottom ash and fly ash.

In summary, with respect to AMR, the county should expect that vendors will be available to provide services whether the feed stream is combined ash or bottom ash. The resulting fee structure ($/ton of ash processed) will be more favorable to the county if performed on bottom ash, but this cost must be weighed against the costs incurred by retrofitting the facility to separate bottom ash from fly ash; this option also entails some additional hazardous waste issues that must be addressed. The county should fully explore the potential cost arrangement with vendors of processing combined ash versus bottom ash.

COMBINED ASH VS. BOTTOM ASH: AGGREGATE RECOVERY

Although AMR from ash is not as common in North America as in Europe, several facilities have been in operation for a number of years across the U.S., and more are planned. Unlike Europe, recycling of mineral aggregate produced from ash is still in the early phases. Florida has had several demonstration projects utilizing bottom ash, and a reuse demonstration project involving aggregate produced from combined ash is currently going through permitting for Hillsborough County. When discussing the relative merits of using combined ash or bottom ash as a feedstock, it is useful to first describe the different potential ash recycling markets.

Aggregates produced from ash can potentially be used in several different construction applications. These include as a replacement for construction stone in road base (or similar construction projects) and as an aggregate in Portland cement concrete (PCC) and hot mix asphalt (HMA) pavement. For the structural base option, a mix of both finer and coarser aggregates are desired. When used as a partial aggregate replacement in PCC or HMA, a more select gradation range will typically be targeted (e.g., coarser aggregates for PCC). Another potential market for ash is use as a cement kiln feed. Cement kilns rely on raw minerals and waste products to provide the necessary calcium, silica, aluminum, and iron for the cement manufacturing process. WTE ash can potentially supply these minerals, in part.

With respect to physical and chemical differences between these ash streams, several contrasts stand out. Combined ash will contain more fine particles as a result of the added fly ash; the fine particles in fly ash tend to contribute more calcium compared to bottom ash and less aluminum and iron. Combined ash contains more salts (e.g., chloride, sodium) in comparison to bottom ash. Moreover, some elements such as arsenic and cadmium exist in higher concentrations in fly ash compared to bottom ash, and thus combined ash concentrations of these elements also tend to be higher.

When ash is recycled as a mineral product in Europe, bottom ash serves as the feed source. Most of the development work in the U.S. (including Florida) has also focused on bottom ash. Thus, in the U.S., the current body of research and experience on Ash recycling is much more extensive on bottom ash compared to fly ash (there is relatively less published information on recycling of products derived from combined ash). Some research has been conducted on recycling mineral products from combined ash, however, and this does suggest that
manufacture of viable construction products may be feasible. Some important points to note on the difference between fly ash and bottom ash are as follows:

- Combined ash does leach some elements at greater concentrations than bottom ash, thus environmental permitting of this option will require more rigorous evaluation. It is important to note, however, that the leached concentrations observed with combined ash mineral products are not dramatically higher than what has been observed with those produced from bottom ash. The leached concentrations observed with combined ash mineral product exist at a level that can still be at typical dilution and attenuation thresholds.
- Aggregates produced from combined ash have in general been found to provide suitable physical properties for road base and for aggregate use in PCC and HMA. Longer-term performance issues still need to be evaluated, but preliminary data have not found combined ash mineral products to be inadequate for reuse.
- The levels of chlorides and alkalis in combined ash will limit the use of ash as cement kiln feed.

In summary, with the current state of knowledge and performance, mineral products produced from bottom ash will likely be much easier to permit and bring to market compared to those produced from combined ash. Recycling of mineral products from combined ash will likely be limited to a smaller scope of potential applications compared to similar products from bottom ash. Preliminary research in Florida does, however, find that products from combined ash can meet typical performance properties for many reuse markets, and with proper engineering and/or institutional controls in place, typical environmental risk safeguards can be met. Because of the unknowns, a more rigorous analytical testing program will be required for projects proposing recycling of products from combined ash.

3.5.3 Ash Management at the Facility:
At the Pinellas WTE facility bottom ash (from each ash extractor) is currently combined with fly ash which has been processed through a pug mill and the combined stream is then transported into the ash processing building. As designed, the following represents the process flow for the existing ash system:
Figure 3.19 Process flow for the existing ash system

- The combined ash passes over a screen to separate the > 5” material (A).
- The < 5” inch material (B) is conveyed to a rare earth magnet for ferrous recovery. The ferrous material is collected in a bunker (C).
- After the magnet, the “ferrous free” residue passes over a 3/8” screen.
- The <3/8” material passing through screen is residue for disposal (D).
- The >3/8” material passes over the eddy current separator (ECS) (E).
- The non-ferrous material is collected in a bunker (F).
- The >3/8” residue material from the ECS is dumped on the floor as residue for disposal (G).

A number of basic approaches for ash management can be taken to improve metals recovery. Equipment suppliers each provide their own approaches and have their own equipment, some of which may be proprietary. Approaches are discussed below and have been grouped into the following basic concepts:

- metals cleaning
- enhanced metals processing
- regional metals processing

3.5.4 Metals Cleaning Facility

Metals cleaning is a basic approach to improving the quality and thus the value of the metals produced. Cleaner metal results in a higher yield and less slag for the mill processing the scrap and thus has increased value for their operation.
Metal cleaning can be completed in a number of ways. As the metal dries, the ash associated with the metal becomes less sticky and re-handling the metal will result in a loss of impurities. Some facilities have used a crane or grapple fitted with a magnetic head to load ferrous metal. At Pinellas, this approach could be applied to the > 5” Material A and separately to the Ferrous Product C. The ash and impurities will slowly build up in the metal storage areas until it becomes necessary to loadout the residual material. This ash-rich residual material could be re-processed to recover the remaining ferrous. In this manner the ash and impurities are combined with other ash. This approach increases the yield but may be too slow and labor intensive for the ferrous cleaning operations. It is an effective means of removing larger impurities such as tires, tree stumps, and stainless steel for the > 5” Material A and thus it is often used for oversized ferrous cleanup. It can also reduce contamination in the Ferrous Product C improving the product quality. However, it is generally less effective than some other cleaning approaches.

Another approach to metals cleaning is to process the ferrous metal through a trommel screen. The tumbling action in the screen tends to dislodge the ash and some scale from the ferrous. The holes in the trommel screen can be sized to separate the ash and smaller impurities from the ferrous product. The ash and smaller ferrous metal falls through the holes leaving the larger, higher yielding ferrous metal as the remaining product. Ferrous Product C could be processed through a trommel screen to remove ash and smaller ferrous. It may be possible to add the trommel within the current processing area if there is adequate space. Processing near the ferrous metal storage area and ash loadout area will reduce operating costs. Possibly the Ferrous Product C could feed directly to the trommel screen. Incorporating the trommel into the processing line does not allow the metal to dry and may mean that some ash will continue to stick to the metal but generally a high percentage of ash will be dislodged. At some facilities due to space constraints, to allow the ferrous to dry, or for other reasons, the metal is separated and allowed to dry before processing in a trommel. Due to the size and mix of the material, this cleaning approach is less effective for the > 5” Material A.

If space is an issue, a front-end loader could be fitted with a flip screen attachment. The flip screen replaces the front-end loader bucket, and looks similar to a trommel screen mounted across the front of the loader with an opening in the side of the screen. It is powered by the loader and can be rotated in either direction. The screen is designed to allow a batch of metal to be scooped into the screen for processing. The loader would then move to the Residue G location. By spinning the screen in one direction, the Ferrous Product C can be tumbled, dropping the ash and small metal through the screen holes. Once the ash has been separated, the loader moves to the ferrous storage area or container and reverses the direction of the screen rotation to drop the metal from the screen. This technique is very effective at removing ash and small metal. It cannot process > 5” Material A due to size limitations and does not remove larger impurities. It is faster and more effective than using a grapple with a magnet but is a batch processing approach and does have throughput limitations.

A hammer mill shredder followed by a second magnet is used at some facilities to clean and size ferrous metal. After the existing process separation > 5” Material A and the Ferrous Product C can be processed through a hammer mill. The hammer mill will reduce the size of larger metal such as tire rims or metal containers increasing the density of the project and improving
shipping weights. The metal will be forcibly cleaned as it is sized and pushed through the hammer mill sizing screen. This process will remove nearly all ash and slag even if the slag is initially fused to the metal. After processing through the hammer mill, the second magnet is able to separate the ferrous metal from the ash/slag with little ash being carried over. This approach generally offers a high quality ferrous metal product. In the process of shredding, more small ferrous metal pieces will be generated. If necessary, this smaller ferrous can be separated with a trommel or other suitable screen. This approach produces a quality ferrous product that is clean and is denser than other cleaning approaches allowing road legal weights to be achieved more easily. If a trommel or other screen is used to remove the smaller ferrous, the quantity of metal produced is lower but the price per ton may be higher. At the Complex, there is not adequate space for the shredder, conveyors, and other equipment required in the existing ash building. The system cost is higher than for other approaches due to the space requirements, larger quantity of equipment, equipment cost, and extra handling of metal and ash. The system is designed for continuous operation and can have a high production rate thus reducing the required hours of operation for metals cleaning.

Another approach that can be used for cleaning metal is a wet system. Both the Ferrous Product C and the > 5” Material A metal can be washed to remove loose ash. The wash water can be recirculated to reduce consumption. Washing the ferrous metal can increase the corrosion as the product dries. Washing may not remove some slag deposits and depending on how the system is set up some water may remain with the ferrous in tin cans and other pockets. Washing will require water makeup and disposal of the sludge removed from the metal. A filter press or other waster separation system will reduce water loss and sludge disposal. Washing will not size the ferrous or remove larger contaminants such as stainless steel or wood unless a magnet is added. A trommel could be provided to remove the smaller ferrous if needed and would also help remove water. It is likely that additional space would be necessary for the equipment thus requiring extra handling of the metals. Generally, it is not desirable to wash ferrous metal due to the resulting wastewater treatment and sludge disposal required.

Non-ferrous metal (+3/8” non-ferrous F) is generally cleaner than the Ferrous Product C and usually does not require cleaning if sold as mixed non-ferrous metal. If non-ferrous metal is sorted and sized, certain components may be cleaned as discussed in the enhanced and regional processing option below.

As part of the metal cleaning process, ash sizing and screening can be incorporated with or after the metal cleaning process. After the metal cleaning measures have been completed, the residue from the metals cleaning can be recombined with the ash material. If the applications for ash re-use are sensitive to ferrous content or moisture, it may be desirable not to blend the metal cleaning residues with the ash. The ash can be screened to various sizes using either a series of vibrating screens such as a Bivitec screen or multi hopper size segmented trommel screen. These types of screens are designed for processing ash without blinding the openings. Trommel screens with holes less than about an inch may bind with wet ash residue. Ash aggregates of varying size ranges can be produced in one or more steps to support aggregate production for mechanically stabilized walls. If required, metal removal from the ash aggregate products can be provided.
3.5.5 Comparison Summary

ENHANCED METALS PROCESSING FACILITY
An enhanced metals processing facility would clean and prepare the metals beyond more usual cleaning measures. The Complex is large enough to consider such a facility for the fresh ash generated and potentially for mined ash from the landfill. Additional recovery of metals not currently being captured by the facility's metals recovery system would have to be completed.

As for metal cleaning, a number of additional approaches could be taken. Enhanced systems are more sophisticated and dependent on approaches the selected vendor employs to complete the metal recovery and ash conditioning. The techniques used, and performance, are often closely held by the vendor. Basic examples are discussed in this section.

Additional measures could be applied to recover more metal from the residue produced at the existing ash handling facility. These types of systems size the residue and arrange the magnets, ECS units, and screens to more effectively capture and sort the metal in various residue size ranges. The value of ferrous metal is dependent on the yield in the mill and the yield increases for larger scrap. Smaller ferrous metal is removed from the ash residue to improve the properties of the residue and to protect the ECS units from damage due to ferrous metal. The smaller ferrous has less value but in some cases can be sold as is or be blended with larger ferrous metal.

The enhanced metals systems focus mainly on recovery of more non-ferrous metals missed by the existing metal recovery system. Separating the metals by type increases value. Different sizes of non-ferrous materials in the residue tend to be certain types of metal. For instance, larger non-ferrous materials captured by an ECS often tend to be copper and brass that did not melt in the furnace. Aluminum melts into nuggets that are generally smaller than the brass fittings and copper components in the ash and thus screening before the ECS can begin to concentrate the metals by type from separate streams, thereby increasing value. Some enhanced metals recovery systems may continue to subdivide these metals by using ballistic or density separation as the brass and copper are heavier than aluminum.

Some enhanced systems go beyond the conventional non-ferrous recovery by processing the smaller ash residue. The existing ECS at the Complex is not arranged to capture non-ferrous smaller than about 3/8” as this material passes through a screen as -3/8” Unders D and leaves the facility with the larger +3/8” Residue G. Usually enhanced metals recovery systems use an ECS to capture the non-ferrous metal in this residue. This non-ferrous does not have as high a yield at the mill but it has a higher percentage of copper and contains some precious metals such as silver and gold from electronics processed in the combustors, and thus may be worth recovering.

Stainless steel is a non-ferrous (non-magnetic) metal that is not readily captured by an ECS. A few facilities have experimented with induction separators to capture stainless steel and some other metals that will conduct electricity but are not readily captured with magnets or an ECS. The induction separator is located after the magnet and ECS so it only captures the remaining metals not recovered by those devices. Experience has been mixed and due to the limited value and quantity for most of the remaining metals, this technology is not widely used. Since
stainless steel items do not melt and most are relatively large, a high percentage ends up in the +5” Overs A. Some facilities have found it to be worthwhile to hand pick the stainless steel, motor windings, and other metals from the +5” Overs A, selling each as a separate product.

Coin and jewelry separation can be completed using specific types of screening techniques. Coins are generally worth more for their face value than the metal content. Undamaged coins can be returned to banks for face value. Damaged coins may have redemption value provided certain federal rules and authorizations are completed. Some vendors have found great value in washing the coins so they can be inspected and then sorting old and rare coins from standard currency. In a similar manner gold and precious jewelry can be sorted from costume jewelry.

Mobile enhanced metals recovery systems are available from a number of vendors. These units are designed to be set up generally at an ash monofill and may process both fresh ash and mined ash to recover metals. Since they are mobile, they can be relocated as needed or employed for trial runs and demonstration periods as is planned for the Complex. These systems may not separate the recovered metals into as many products but may be a cost effective means of recovery while demonstrating whether a permanent system is warranted.

If the WTE facility ash management process is re-developed, potentially the existing ash building could be modified to incorporate an enhanced metals recovery system. This would be particularly useful with separate handling of fly ash and only processing bottom ash through the enhanced system. After metal recovery, the facility fly ash can be mixed with enough bottom ash so the combined ash complies with ash quality requirements. This combined ash can continue to be placed in the landfill if re-use is not possible. The remaining bottom ash would then be available for reuse as aggregate for mechanically stabilized walls or other applications.

REGIONAL METALS PROCESSING FACILITY
While the WTE facility is large enough and produces enough ash to warrant consideration of an enhanced metal recovery system, a regional metals processing facility may improve economics. Some or all of the WTE facilities in the region or throughout the state could cooperate to process ash residue for enhanced metals recovery. By working together larger quantities of ash could be processed increasing the quantity of metal available for sale, thus providing a better negotiating position. The larger quantity of metals would mean that the sorting equipment could be run more economically for longer hours or more shifts, or with larger more economical equipment. The increased quantity of non-ferrous metal may also allow use of other techniques separating the metals into even more specific higher value products. Potentially shipment of full barges, rail cars, or dedicated ship capacity could improve economics. Greater opportunity to experiment with labor-saving or enhanced recovery techniques would be possible.

Pinellas may be well suited to host such a facility. Proximity to rail and port facilities and a collection of a number of WTE facilities in the area improve opportunities. If a coalition of facilities band together it may be possible to attract competition from several vendors, each capable of providing and operating a regional facility.

A centralized facility may also improve opportunities for increased re-use for some or all of the ash. Improved bargaining power with state agencies may help with obtaining beneficial use
permits for ash re-use that are less restrictive than current ash re-use permits in Florida. Aggregate is in short supply in Florida and thus has higher value than most other parts of the U.S. More specific grading of the ash and the increased steady supply may increase opportunities for aggregate markets.

SUMMARY AND COMPARISON OF METALS PROCESSING ALTERNATIVES
The following Table 3.4 summarizes the metals processing alternatives.
<table>
<thead>
<tr>
<th>Type of Facility</th>
<th>Metals Cleaning Facility</th>
<th>Enhanced Metals Processing</th>
<th>Regional Metals Processing Facility</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Magnetic Grapple Re- Cleaning</td>
<td>Trommel or Bivitec Screen</td>
<td>Flip screen</td>
</tr>
<tr>
<td>Materials Processed</td>
<td>A and C Ferrous only</td>
<td>C and possibly A Ferrous only</td>
<td>C Ferrous only</td>
</tr>
<tr>
<td>Effectiveness</td>
<td>Works best after letting metals dry not as effective removing slag</td>
<td>Works best with dry metal but will clean better than a grapple will not remove non-ferrous</td>
<td>Works best with dry metal but will clean better than a grapple will not remove non-ferrous</td>
</tr>
<tr>
<td>Relative Processing Rate</td>
<td>Slow</td>
<td>Continuous and can be scaled up</td>
<td>Batch process, slower processing rate</td>
</tr>
<tr>
<td>Metal Sizing</td>
<td>Will keep some smaller ferrous</td>
<td>Will remove small ferrous</td>
<td>Will remove small ferrous</td>
</tr>
<tr>
<td>Type of Facility</td>
<td>Metals Cleaning Facility</td>
<td>Enhanced Metals Processing</td>
<td>Regional Metals Processing Facility</td>
</tr>
<tr>
<td>------------------</td>
<td>--------------------------</td>
<td>-----------------------------</td>
<td>-----------------------------------</td>
</tr>
<tr>
<td>Cost</td>
<td>Low</td>
<td>Low</td>
<td>Medium</td>
</tr>
<tr>
<td></td>
<td>Low</td>
<td>Low but need to address sludge and wastewater</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Low</td>
<td>High</td>
<td>High but less than a fixed system</td>
</tr>
<tr>
<td>Ability to use in existing ash building</td>
<td>Yes, but ferrous will not be fully dry</td>
<td>Possibly</td>
<td>Possibly with significant modifications</td>
</tr>
<tr>
<td></td>
<td>Yes, but ferrous will not be fully dry</td>
<td>Would need a building extension or separate building</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Would need a building extension or separate building</td>
<td>Possibly with significant modifications</td>
<td>Would need to re-build existing building</td>
</tr>
<tr>
<td></td>
<td>Would need a building extension or separate building</td>
<td>Possibly with significant modifications</td>
<td>No, locate at landfill or in a temporary arrangement</td>
</tr>
<tr>
<td>Use Water?</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td></td>
<td>No</td>
<td>No</td>
<td>Possibly</td>
</tr>
<tr>
<td></td>
<td>No</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td></td>
<td>Yes</td>
<td>Yes, but can be managed</td>
<td>Yes, but can be managed</td>
</tr>
<tr>
<td>Sensitivity to fly ash</td>
<td>Very</td>
<td>Less sensitive if metal is dry</td>
<td>Less sensitive if metal is dry</td>
</tr>
<tr>
<td></td>
<td>Less sensitive if metal is dry</td>
<td>Less sensitive</td>
<td>Increases sludge generation and water use</td>
</tr>
<tr>
<td></td>
<td>Less sensitive</td>
<td>Yes, but can be managed</td>
<td>Yes, but can be managed</td>
</tr>
<tr>
<td></td>
<td>Increases sludge generation and water use</td>
<td>Yes, but can be managed</td>
<td>Yes, but can be managed</td>
</tr>
</tbody>
</table>
3.6 Bulky Waste Processing Facility

Bulky wastes are problematic for processing/disposal at the county’s WTE facility and the landfill. At the WTE, if identified on the tipping floor or pit, often the front-end loader or crane operator will spend time trying to crush the object, if appropriate for processing, or will separate the un-processible waste from the other waste. The un-processible waste is set to the side for subsequent handling. If an oversized object gets into the processing unit, it can cause a chute plug or grate bed issues disrupting operations. At the landfill, bulky wastes consume air space due to their low density and cause other operational problems.

Processing these materials, however, can result in a quality fuel product for the WTE facility, metals recovery, other recyclables recovery, and save landfill air space in an environmentally responsible manner. Various approaches have been applied to bulky waste processing, and the range of materials handled may vary depending on local needs.

An enclosed bulky waste facility typically has a large processing floor where the various types of materials processed are received. Materials received are inspected and sorted as required for processing. Generally, a facility has a large shredder capable of handling the largest anticipated materials that will not be precut. Depending on capacity, a large shear or rip type high torque shredder may be used. This style of shredder is generally more effective than a hammermill type shredder for sizing materials such as carpet or mattresses. Great care must be taken in the inspection process to remove containers with flammable liquid or gas. These shredders have the advantage of being less likely to have an explosion or fire if a container is accidentally fed into the unit. A shear or rip type shredder will tend to produce strips of carpet or other materials but this should not be an issue for processing at the WTE facility. In some cases, an object such as a foam mattress or tire may simply be compressed and pulled through the machine, re-expanding after processing to be almost unaltered afterwards. If needed these items can be re-fed through the unit.

Most bulky waste facilities accept certain types of appliances, metal shelving, and similar items. Appliances containing Freon need to be set aside for recovery of the refrigerant before processing. Air conditioning units, refrigerators, freezers, and other Freon-containing devices need to have Freon recovered prior to processing. These appliances can be stockpiled and either a properly trained and certified employee or a service company can be arranged to recover the Freon prior to processing.

At some facilities removal of circuit boards, motors or other components may be required or is completed because some items can be sold separately for higher value. Mercury switches should be removed and handled appropriately. Any liquids or liquid-containing components are removed and the liquids properly managed.

Once prepared, the metal objects and appliances can be shredded. It may be best to process the metal objects separately from other materials to achieve a cleaner metal product. A magnet on the downstream processing line can recover ferrous metal. Depending on cleanliness, the ferrous metal can be sold, and is generally more valuable if sold prior to combustion, rather sending it through the WTE facility. Non-ferrous metal can be recovered as well. Remaining plastics and other combustible materials can be added to the other shredded combustibles for further processing in the WTE facility.
Processing these materials can generate additional fuel for the WTE facility, provide for metals and other recyclables recovery, and save landfill air space.

As discussed, various approaches can be used to process bulky waste and the range of materials handled varies. Depending on the type of materials received and the degree of processing/separation desired, bulky waste processing equipment can include a shredder, grinder, crusher, screens, magnets, manual sorting line, baler, possibly a ballistic separator and potentially an eddy current separator. Depending on future operations undertaken by the county, a facility for processing bulky waste could be placed west of the MINI using a portion of the available land in this location. Placement within a building would avoid certain environmental permitting constraints although dust control and other worker safety measures would need to be considered. As this area, regardless of operations developed, will increase site movement of customers and internal traffic, access and egress to scales and other locations onsite will need to be more fully evaluated.

3.7 Use of Existing AD WWTP Capacity for Organics

The anaerobic digestion of wasted food is one of the most preferred options of the U.S. Environmental Protection Agency (EPA) wasted food recovery hierarchy, following source reduction and feeding of hungry/need people, and finally animals. Anaerobic degradation of wasted food produces biogas, which primarily consists of methane that can be beneficially used in heat or power generation. The county has a total of five anaerobic digesters (ADs) at the county’s different wastewater treatment facilities or water reclamation facilities (referred herein as WRFs). The following sections discuss the feasibility of processing the county-generated wasted food at WRFs with ADs.

3.7.1 Co-Digestion of Wasted Food with BioSolids in Anaerobic Digestors

Over the past decade, anaerobic digestion of wasted food at ADs installed at WRFs has significantly increased. Based on an analysis of the Water Environment Federation’s WRFs database (WEF, 2018), Pennington (2018) reported that approximately 20 percent of 1,200 WRFs with ADs in the U.S. are co-digesting biosolids along with other materials including wasted food. Pennington conducted an extensive survey of WRFs with AD in the U.S. and reported that seventy-two of the responding WRFs with ADs co-digest biosolids with other organics such as fats, oils and grease (FOG) and wasted food; over 85 percent of these responses indicated co-digestion of biosolids with FOG (Figure 3.20). Other wasted food streams accepted at these facilities were food processing industry waste, beverage processing industry waste, and pre- and post-consumer food services waste.
Figure 3.20 Top feedstocks accepted by ADs among 72 WRF (Pennington, 2018)

As shown in Figure 3.21, the major wasted food sources at these facilities were restaurants and food service, food and beverage processors, municipal and residential sector, industrial sector, and grocery and supermarkets. Based on IWCS/HDR estimates, over 55 percent of wasted food generated in the county is from restaurants and food service.

Several of the surveyed WRFs with ADs accept only the FOG portion of wasted food as FOG do not require much pre-processing for co-digesting with WRF sludge. The county currently accepts FOG for co-digestion at its WRF AD facility. Other types of wasted food typically require pre-processing such as de-packaging, screening, chopping, grinding, and/or pH adjustment prior to feeding it into digesters. A total of 30 of 72 WRFs provided pre-processing details to the Pennington survey. Approximately 50 percent of those have some provision for screening and sorting the debris (Figure 3.22). The pre-process was contracted out at 37 percent of these WRFs.
Figure 3.22 Specific pre-processing of wasted food for co-digestion at ADs among 30 WRFs (Pennington, 2018)

Pennington reported out of 72 WRFs that co-digested wasted food, over 90 percent of the WRF ADs operate in mesophilic temperature range (86-100 °F) while the rest operated in the thermophilic (122-140 °F) temperature range. In an anaerobic digestion process, the destruction rate of volatile solids (VS) present in wasted food is approximately 86 to 90 percent greater than the biosolids which allows a higher VS feeding rate than the biosolids (EPA, n.d.). An AD operating at mesophilic temperature range with 15-day mean cell residence time, the wasted food VS loading rate can be as high as 0.28 lb/ft³-day as compared to 0.2 lb/ft³-day, a typical VS loading rate for biosolids in ADs. Wasted food anaerobic digestion also has up to three times more energy potential than biosolids (EPA, n.d.). The biogas generated by the ADs can be used in on-site applications including heating the ADs, sludge filtration and drying, and electricity generation. Pennington reported that of the 72 WRF, 51 (71 percent) facilities used biogas for generating heat and electricity and 44 (61 percent) facilities used it as fuel for boilers and furnaces to heat digesters, as shown in Figure 3.23.
The biogas produced may need to be processed for removal of sulfur, moisture, siloxane, and/or hydrogen sulfide prior to use in a beneficial use application. Of the 72 WRFs included in the Pennington survey, 47 facilities provided data related to gas cleaning systems used at their facilities and more than 80 percent of those had sulfur, moisture, and siloxanes removal systems as shown in Figure 3.24.

The solids produced after processing can be land applied, used as fertilizer, and/or landfilled. All the 72 survey respondents provided solids residuals management details (Pennington 2018). Pennington reported that all the 72 WRFs provided their solids residuals management details during the survey and, as shown in Figure 3.25, 38 WRFs (approximately 53 percent) dewatered or dried the biosolids and land applied. Sixty-nine (69) of the 72 WRFs indicated that the biosolids produced is Class A or Class B, 20 percent produced Class A and remaining 80 percent produced Class B biosolids. The other
management options include landfilling and/or composting or drying into a reusable product. The liquid discharge from ADs was either recirculated through a digester (86 percent of 72 WRFs) or reused as fertilizer. WRFs appear to use usually one, or in some cases more than one, option for their solid and liquid discharge management.

Figure 3.25 Application of residuals/solids produced from co-digestion systems among 72 WRFs (Pennington, 2018)

3.7.2 Infrastructure Availability at the County for Co-digesting Wasted Food with Bio Solids in Anaerobic Digesters

There are 15 publicly-owned WRFs located in Pinellas County. Two of these are owned and operated by Pinellas County Utilities (PCU). Four WRFs are operated by City of St. Petersburg, three by City of Clearwater, and Cities of Largo, the cities of Tarpon Springs, Dunedin, Safety Harbor, Oldsmar, and the State of Florida Department of Natural Resources each operate one WRF. As mentioned previously, five of these WRFs have AD facilities. Figure 3.26 shows the location of the County’s WRFs with AD. Three of the WRFs with AD are located in City of St. Petersburg. One of these WRFs is owned and operated by PCU and the other two are owned and operated by the City of St. Petersburg. The remaining two AD facilities, which are operated by the City of Clearwater are located in the City of Clearwater and in Safety Harbor.
Figure 3.26 Location of County’s WRFs and ADs

Table 3.5 lists facility operating authority, plant capacity, AD capacity, and other relevant details pertaining to facility’s AD operation as listed in Water Environment Federation’s Water Resource Recovery Facilities with AD dataset (WEF, 2018), and each facility’s most recent permit application submitted to the FDEP. The following sub-sections present a capacity and operational summary of Pinellas County’s WRFs with AD.

SOUTH CROSS BAYOU WRF
South Cross Bayou WRF (SCB-WRF), which is owned and operated by PCU, has a design capacity of approximately 33 million gallons per day (MGD) and is the largest capacity WRF with AD in the County. The SCB-WRF is currently operating at approximately 66 percent of its design capacity and the County projects that the facility will be operating at approximately 67 percent of its capacity by 2025 (Pinellas County, 2007). The SCB-WRF has two ADs of 800,000 gallons capacity each (i.e., a total capacity of 1.6 MG) with a methane gas storage tank (FDEP Permit Number FL0040436, 2018). The SCB-WRF already feeds FOG in its ADs. The incoming FOG is first placed in a dewatering tank and approximately 2,300 tons per year of dewatered FOG is fed into ADs that also accepts waste aerobic sludge from SCB-WRF and other Pinellas County WRFs. The solids produced from ADs is passed through a centrifuge and dried using a drum drier and pellet cooler. SCB-WRF produces approximately 6,000 tons of dried biosolids pellets annually. The methane generated at SCB-WRF is used in the pelletizing the biosolids and excess methane is flared. During 2015,
SCB-WRF saved approximately $140,000 in natural gas expense of the facility’s biosolid pelletizing operation. Based on the recent conversation with the PCU, the ADs at SCB-WRF are operating at capacity and may not accept any additional wasted food.

SOUTHWEST WRF
The Southwest WRF (SW-WRF), which is operated by the City of St Petersburg, has a design capacity of approximately 20 MGD. The SW-WRF is operating at approximately 50 percent of its design capacity. The SW-WRF has two ADs with a total volume of 2.6 MG operated in series (FDEP Permit Number FLA128848, 2018). Additionally, SW-WRF has two gravity belt thickener and two belt filter presses for biosolids management. The biosolids generated are treated using lime and acids to produce Class AA quality biosolid and are used in land application or commercial sales.

The SW-WRF was permitted in May 2018 to add two new ADs of total capacity of 4.28 MG to treat sludge from the Northwest WRF and Northeast WRF located and operated by the municipality of St Petersburg. The ADs are designed to operate as temperature phased anaerobic digesters (TPAD) (i.e., thermophilic followed by mesophilic) and would have the capability to include other feedstock including FOG and pulped food waste. An additional digester gas handling facility is planned to provide momentary gas production peak storage and flare the excess digester gas. An expansion of biosolids thickening and dewatering capacity is also permitted. An engine to produce electricity and heat from biogas is permitted to be installed. Natural gas will be used for the supplemental process heat.

MARSHALL STREET WRF
The Marshall Street WRF (MS-WRF) operated by the City of Clearwater has a design capacity of approximately ten MGD and currently operates at approximately 56 percent of its capacity. The MS-WRF has an anaerobic digester of approximately 1.3 MG. The sludge produced from the AD is dewatered using a centrifuge and a belt filter press4. The AD produces Class B biosolids which are hauled and land applied in agricultural sites5. The biogas produced is used within the facility to heat the digesters and operate the facility’s air conditioning units and excess biogas is flared. The AD is designed to operate as mesophilic (WEF, 2018).

NORTHEAST WRF
The Northeast WRF (NE-WRF), which is also operated by the City of Clearwater, has a design capacity of approximately 13.5 MGD. NE-WRF is operating at a design capacity of approximately 50 percent. NE-WRF has sludge thickeners which feeds to the two anaerobic digesters operating as mesophilic with a combined capacity of approximately 1.9 MG. Thickened sludge from another WRF (East WRF) is also fed in the NE-WRF ADs 6. NE-WRF also has four additional ADs with combined capacity of approximately 0.8 MG. The AD residuals are dewatered using centrifuge and belt filter press and land applied. The biogas produced is used within the facility to heat the digesters and produce electricity for onsite use (WEF, 2018).

ST. PETERSBURG ALBERT WHITTED WRF
The St. Petersburg Albert Whitted WRF (SPAW-WRF) is operated by the City of St Petersburg and has a design capacity of approximately 12.4 MGD. The SPAW-WRF is

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4 FDEP Permit Number FL0021857, 2016
5 Marshall Street Operating Protocol, 2016
6 FDEP Permit Number FL0128937, 2018
operating at approximately 52 percent of its design capacity. Based on the SPAW-WRF Permit Renewal Application (2016), the sludge produced in the wastewater treatment process is first stored in the sludge holding tank followed by thickening using the gravity filters. The thickened sludge is then fed to the two ADs of a combined capacity of approximately 2.4 MG. The biosolids of ADs is dewatered using belt filter press, the information on the utilization of biogas was not available. However, WEF (2018) lists that the ADs at SPAW-WRF were decommissioned. Based on the operational Permit issued in 2017, the SPAW-WRF is currently permitted to store wastewater treatment processes sludge in a sludge holding tank from which the sludge is pumped to SW-WRF through a force-main for its treatment. 7.

Table 3.5 County’s publicly owned WRFs with anaerobic digesters

<table>
<thead>
<tr>
<th>Facility</th>
<th>South Cross Bayou WRF</th>
<th>Southwest WRF</th>
<th>Marshall Street WRF</th>
<th>Northeast WRF</th>
<th>St. Petersburg Albert Whitted WRF</th>
</tr>
</thead>
<tbody>
<tr>
<td>Address</td>
<td>7401-54th Avenue North</td>
<td>3800 54th Avenue South</td>
<td>1605 Harbor Drive</td>
<td>3290 SR 580</td>
<td>601-8th Avenue Southeast</td>
</tr>
<tr>
<td>Location</td>
<td>St. Petersburg</td>
<td>St. Petersburg</td>
<td>Clearwater</td>
<td>Safety Harbor</td>
<td>St. Petersburg</td>
</tr>
<tr>
<td>Operating Authority</td>
<td>PCU</td>
<td>City of St. Petersburg</td>
<td>City of Clearwater</td>
<td>City of Clearwater</td>
<td>City of St. Petersburg</td>
</tr>
<tr>
<td>Design Capacity (MGD)</td>
<td>33</td>
<td>20</td>
<td>10</td>
<td>13.5</td>
<td>12.4</td>
</tr>
<tr>
<td>Average Flow (MGD)</td>
<td>21</td>
<td>10.1</td>
<td>5.6</td>
<td>6.7</td>
<td>6.5</td>
</tr>
<tr>
<td>Digester Capacity (MG)</td>
<td>1.6</td>
<td>4.3</td>
<td>1.3</td>
<td>2.7</td>
<td>2.4</td>
</tr>
<tr>
<td>Outside wasted food fed to digesters</td>
<td>✓</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Outside sludge fed to digesters</td>
<td>✓</td>
<td>✓</td>
<td>x</td>
<td>✓</td>
<td>x</td>
</tr>
<tr>
<td>Biogas utilized</td>
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<td>x</td>
<td>✓</td>
<td>✓</td>
<td>x</td>
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<tr>
<td>Biogas flared</td>
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<td>✓</td>
<td>✓</td>
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<tr>
<td>Biogas drives machinery</td>
<td>✓</td>
<td>x</td>
<td>x</td>
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<td>✓</td>
</tr>
<tr>
<td>Biogas heats digesters</td>
<td>✓</td>
<td>x</td>
<td>✓</td>
<td>✓</td>
<td>x</td>
</tr>
<tr>
<td>Biogas used by HVAC</td>
<td>x</td>
<td>x</td>
<td>✓</td>
<td>✓</td>
<td>x</td>
</tr>
<tr>
<td>Biogas injected to pipeline</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Electricity Generation</td>
<td>x</td>
<td>x</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
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</table>

3.7.3 Summary of County-wide Anaerobic Digestion Capacity

Five of WRFs located within the county have ADs. The county’s combined capacity in the anaerobic digesters is approximately 10 MGD, excluding the AD capacity of SPAW-WRF; 12.4 MGD including the AD capacity of SPAW-WRF. These WRFs are located in St. 7 7 FDEP Permit Number FLA128830, 2017
Petersburg, Clearwater, and Safety Harbor which are densely populated urban areas. Only SCB-WRF accepts FOG to co-digest with biosolids, and all other WRFs use only sludge as a feedstock in their ADs. The biogas generated at these WRFs are generally used for heat generation to operate ADs and drying the biosolids. Among the five WRFs, only NE-WRF located in Safety Harbor generates electricity. The biosolids generated from the ADs are mostly land applied.

3.7.4 Feasibility of Accepting Wasted Food at the County’s WRFs with ADs

As discussed in the Needs Assessment, the county generates approximately 207,500 tons of wasted food per year from its commercial, industrial, institutional, and residential sources. Based on the EPA’s (2016) reported gallons to ton conversion of wasted food (3.9 lbs. per gallons), the estimated volume of wasted food generation in the county is the equivalent of approximately 300,000 gallons per day. Assuming that the received wasted food moisture content of 70 percent (solids content of approximately 30 percent) is fed to the digester at approximately 10 percent solid content, the resulting volume of county generated wasted food would be approximately 900,000 gallons per day, which corresponds to approximately 7.3 to 7.9 percent of the installed AD capacity.

The available capacity of the ADs at SCB-WRF is limited and per discussions with the utilities department consultant, would likely not be able to handle any significant amount of additional material to digest unless the system was expanded. It was noted that there may be some digester capacity available at certain times throughout the year. Excluding SCB-WRF, the other four WRFs are operating at 50-60 percent of the design capacity suggesting a possibility that the ADs at these facilities are operating less than their design capacity. Given that the SCB-WRF is currently accepting FOG, absent the capacity limitations, this appears well suited to accept food waste should the county pursue organized food waste diversion in the future and additional capacity becomes available. In addition, the SW-WRF in St. Petersburg has been recently permitted to increase its AD capacity and the permit describes that the ADs are another possible option and would accept FOG and other wasted food. Initial discussions would include roles and responsibilities regarding modifications required for acceptance and pre-processing of waste and residuals handling, financial considerations, and the likely requirement for an inter-local agreement.

As presented earlier, the FOG content of wasted food does not require much processing to be used as a feedstock in ADs, whereas the other wasted food does. The WRFs intending to utilize wasted food in the AD would need to have a space and capacity for wasted food processing including storage, screening, de-packaging, and grinding. For example, the SCB-WRF has a dedicated FOG receiving area where the trucks carrying FOG discharges into FOG dewatering tanks and dewatered FOG is fed into ADs. The space available for discharging and required processing of wasted food would need to be evaluated to confirm availability and applicability of potential capacity at each facility.

3.8 Recycling Processing Capacity

Currently, approximately two million tons of solid waste per year are generated within Pinellas County. The county’s traditional recycling rate (without renewable credits) is about 55 percent. It is assumed that approximately 1.1 million tons of recyclables are managed countywide, of which over 400,000 tons are from residential sources which include multifamily properties, according to the 2018 FDEP reporting. Most of the 1.1 million tons is
metals, construction and demolition debris, food waste and textiles and not traditional single stream materials from curbside collection. All residential recyclable materials collected within the county are managed through public/private partnerships. These collected recyclables are either directly delivered to privately owned MRFs or are being consolidated at a transfer station, and the consolidated loads are then delivered to a privately owned MRF for processing and marketing.

Continued reliance on the private sector to meet the future needs of the county is affected by the available capacity at these private facilities. Historically, capacity has not been an issue although this has diminished as tonnages have increased without corresponding investment in new facilities. It has been reported that, in some cases, certain facilities are being operated at capacity and cannot take on additional material. One possible alternative is for the public sector to develop a publicly-owned MRF complete with advanced separation and sorting technologies, although investment in technologies to meet the current 0.5 percent contamination standard for exports may sway the economic feasibility of the facility. Doing so would allow processing capacity to be defined for users of the facility and this capacity could be secured through interlocal agreements. Factors to be considered in developing a publicly owned MRF include the ability to secure financing for the project, securing the feedstock, sizing of the facility, location, selection of the appropriate processing technologies, operation and maintenance costs, and securing required permits and approvals. Part of successful operations of a MRF is the ability to secure end markets for materials. These are variable and under current market dynamics can result in a net operational loss.

3.9 Material Recycling Facilities
To help combat low public participation rates of traditional source-separated curbside collection recycling programs and minimize collection costs, some communities are turning to single-stream collection. Single-stream collection allows all designated recyclable materials to be collected in one bin thus reducing collection costs. The recyclables are typically direct hauled to a clean MRF to be separated and sorted mechanically. Once sorted, the recyclables are typically baled and shipped to end-users or other facilities for further processing.

Given the current recycling business climate, the quality of separation and sorting has become of paramount importance. Much of the recyclable material collected in the U.S. has been sold to China. However, because of the relatively high amount of waste contamination, China has recently adopted regulations to limit such contamination. China’s National Sword Program is now restricting contamination of recyclables to 0.5 percent. Typical contamination levels for single stream feed stocks are 10 to 20 percent. A well-managed MRF (or mixed waste processing facility (MWPF)) may be able to achieve a sorted recyclable commodity with 1.5 to 2.5 percent contamination. To reach these more stringent levels of contamination to allow continued sales to China, many MRFs are running recyclables through their process lines multiple times or they are upgrading their equipment to include advance separation such as magnets, eddy current separators, grates, optical scanners/sorters, and pneumatic separators, followed by manual hand picking to “polish” the final recyclable product. While domestic markets are emerging, relaxation of the 0.5 percent standard by these domestic processors is unknown in the long term. MRFs are concentrating on marketable commodities such as ferrous and trace metals, aluminum,
paper, plastic, and cardboard. In some cases, glass is no longer being accepted as a recyclable due to its weight (up to 40 percent of the total recyclable stream), its low value, safety considerations, and the potential to cross-contaminate other recyclable commodities with glass shards.

3.9.1 Clean MRF Advantages
- Single collection vehicle
- Can manage various types of recyclable materials
- Can reduce contamination to the 1.5 to 2.5 percent level, but may struggle to meet 0.5 percent standards in foreign markets
- Compatible with WTE, landfill, AD and/or composting technologies

3.9.2 Clean MRF Disadvantages
- Additional capital cost and operating cost
- Heavily dependent on a currently unstable recyclables market
- Contamination results depend on quality of operator and increasingly sophisticated separation equipment

3.9.3 Size
As an example, assume the county desires to construct a new MRF in the next five to seven years capable of processing 200,000 TPY of single-stream and source-separated recyclables. An area of approximately 7-acres would be necessary to accommodate it. For a completely indoor operation, a MRF that is 500’ x 300’ in length (150,000 square feet) is a reasonable estimate. A proposed tip floor area is a 100’ x 300’ fitted with 12-foot high poured concrete walls to allow for storage of recyclables and some flexibility in processing. To process 200,000 TPY, it is assumed that two processing lines would be needed to separate recyclables. These processing lines would be equipped with mechanical, optical, magnetic, pneumatic, and human separation techniques. Each MRF processing line is estimated to be 100’ x 350’. Two high capacity 40 TPH single ram balers are assumed. For this example, a single story, 7,500 square feet addition will be assumed for administrative offices and locker rooms.

MRFs today are typically designed to:
- achieve a contamination rate of post-consumer fiber in the 1.5 to 2.5 percent range.
- be able to separate sorted office paper (SOP) from the mixed paper stream, if desired.
- process fiber at a rate of at least 8 tons/hr.
- process old corrugated cardboard (OCC) within the single-stream feed stock in the 25 percent range and allow for deliveries of isolated source separated OCC.
- sort ferrous scrap, tin, aluminum, and other non-ferrous metals.
- sort plastics with a contamination rate of less than 5 percent into the following commodity streams:
  - #1 PET
  - #2 HDPE natural
  - #2 HDPE colored
  - #5 Polypropylene
  - #3-7 Polypropylene
process and sort glass.

3.9.4 Capital Costs
In many ways, modern clean MRFs are more similar to MWPFs than traditional dirty MRFs or transfer stations as added separation and processing equipment can make up a large portion of the capital costs. For estimating purposes, HDR has relied upon MWPF capital costs as they included advanced sorting and separation equipment.

In 2018, HDR developed a conceptual site layout and building size and design for a client in New England. The conceptual cost (Class VI opinion of probable construction cost) was approximately $300/square foot for a modern, clean MRF including site work and building cost; separation, sorting and baling equipment was not included. Equipment was estimated to be an additional $15 to $20M.

3.9.5 O&M Costs
O&M costs consist primarily of labor, equipment maintenance, and disposal costs for residue. Based on the table below, the average O&M cost was $54.25 per ton received. In general, O&M costs are higher for smaller facilities and decrease as the tons per day increases due to economies of scale. Combining feedstock regionally may provide economies of scale that could support development of a publically owned MRF. According to a 2015 RRS webinar, the range of O&M Costs for single-stream processing was between $36 and $50 per ton received and the total cost including administration and capital costs is $45 to $65 per ton received(A). The O&M costs below do not include costs to dispose of residual materials.

Table 3.7 summarizes available cost data for MWPFs in the United States.

<table>
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<tr>
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<tbody>
<tr>
<td>Western Placer Waste Management Authority, Roseville, CA</td>
<td>1,200</td>
<td>$40M</td>
<td>$17M</td>
<td>$33,000</td>
<td>$65</td>
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<td>Infinitus Renewable Energy Park, Montgomery, AL(2)(3)</td>
<td>~700-800</td>
<td>$42M (Phase 1)</td>
<td>Closed in 2015 for Financial Restructuring Citing Falling Recyclable Market</td>
<td>$56,000</td>
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<tr>
<td>Sun Valley MRF, CA (1)</td>
<td>1,500</td>
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<td></td>
<td>$37,000</td>
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<tr>
<td>American Forest &amp; Paper Study(4)</td>
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<td></td>
<td>$49,000</td>
<td>$52</td>
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<tr>
<td>Sunnyvale Materials Recovery and Transfer Station (SMaRT Station©), Sunnyvale, CA</td>
<td>1,500</td>
<td>$21M</td>
<td>$13M (FY2011/2012)</td>
<td>$14,000</td>
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Notes:
3.9.6 Costs-Per-Ton/Day

Figure 3.27 below provides a capital cost curve based on the reported capital costs of five MWPF developed in the United States. Capital costs from previous MWPF construction projects were adjusted to 2018 dollars.

![Capital Cost Curve](image)

**Figure 3.27 Capital cost curve for MWPFs**

3.9.7 Critical Path

Assuming adequate space is available on the county’s property and minimal public opposition, development of a new MRF typically takes approximately three to five years to design, permit, and construct. Offsite development would add time for site selection and acquisition, zoning and permitting for development. This timing is dependent on several factors but can be assume to be at least one to two years\(^8\).

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4 Overview of Waste Management Technologies

The following sections describe a wide range of potential solid waste processing and conversion technology options for consideration as the County evaluates its processing and disposal needs over the planning period. As the technologies below are being evaluated, bear in mind that many are still in various stages of development and may not be commercially proven in the United States. However, solid waste conversion technologies are rapidly evolving, particularly outside of the U.S., and some of these processes may need to be revisited in the near future. It is also important to note, that many of the technologies identified would need to be implemented in combination with one or more of the other technology options. For example, a thermal gasification technology would need to be combined with a front-end mechanical separation system to prepare the incoming waste for thermal processing, and a landfill to handle the residual waste left over from the process. It is a current benefit that the county has over 80 years of capacity at the Bridgeway Acres and Sod Farm landfill areas to allow time for exploring new waste conversion technologies and various combinations of technologies.

The following sections describe the array of technological options available for processing MSW and describes each technology’s potential applicability to the county’s waste stream.

Thermal Technologies

- Direct combustion (traditional waste-to-energy similar to the existing County Facility)
- Gasification
- Plasma arc gasification
- Pyrolysis

Biological Technologies

- Aerobic composting
- Anaerobic digestion with biogas production for electricity or fuel generation
- Mechanical biological treatment (MBT)

Chemical Technologies

- Hydrolysis
- Catalytic and thermal depolymerization
- Waste-to-fuel technologies

Mechanical Technologies

- MWPF/MRF
- autoclave/steam classification
- refuse derived fuel (RDF) production

A general description and qualitative summary for each technology option is included, as well as a summary comparison of the technologies. The summary comparison includes the following:
• the current stage of development of the technology (i.e., commercial readiness);
• the minimum and maximum amount of non-recovered discards that the technology can process and the approximate range of the optimal throughput capacity;
• the potential type of products produced by the technology;
• the approximate range of useful operating life;
• typical or commonly cited environmental benefits and drawbacks of the technology; and
• the pros and cons of the technology.

The information on technology options and the technical considerations associated with each option was gathered by HDR from a number of sources, including:

• HDR’s in-house project and library files compiled from a number of similar recent projects and studies;
• technology vendor supplied information; and
• data and information available in the literature.

4.1 Thermal Technologies
One potential option for the county going forward is the addition of additional processing capacity, either through an expansion of the existing WTE facility or the addition of a stand-alone unit. Thermal technologies are designed to use high temperatures, either by combustion, gasification, or pyrolysis, to convert the carbonaceous materials in MSW into a gas and other solid by-products (ash/char), and recover the caloric energy contained in the waste to produce an energy product. Traditional thermal processes (such as WTE technologies similar to the county’s WTE facility) that produce electrical power do so by using a boiler to recover the latent heat in the exhaust gas produced by combusting the waste to produce steam that drives electrical generators. Some thermal processes may also sell the steam directly to a commercial/industrial user. Thermal processes that convert the waste to produce a fuel or synthesis gas (i.e., gasification, plasma arc gasification (PAG) and pyrolysis) will either combust that fuel gas directly in a boiler to make steam and electricity, or combust the gas in an engine or gas turbine to make electricity. In either case, the direct combustion or gasification of the waste produces certain types of constituent air emissions at certain quantities that vary depending on the type of technology. In all technology cases, modern air pollution control (APC) devices are required to reduce emissions below the applicable FDEP and EPA emission standards. Some of the typical regulated air emission constituents produced by thermal technologies include, but are not limited to, carbon dioxide (CO₂), water vapor, particulate matter, carbon monoxide (CO), nitrogen oxides (NOx), sulfur oxides (SOx), hydrogen chloride (HCl), and some products of incomplete combustion (e.g. dioxins/furans). New thermal technologies are expected to utilize modern APC devices and the array of APC equipment available for use in minimizing air emissions are diverse and proven to be effective at controlling and reducing the release of these emissions to the environment.

4.1.1 Direct Combustion
Direct combustion of waste, often referred to as WTE, involves the complete oxidation of a fuel by combustion under controlled conditions. The heat generated from the combustion process is recovered in a boiler to generate steam which can be used directly for heating/industrial purposes or passed through a steam turbine-generator to create electricity.
There are several types of direct combustion technologies; the most popular include: 1) mass burn with a grate system, similar to the County’s WTE facility 2) stoker-fired, 3) modular starved-air systems, and 3) fluidized bed combustion. Mass burn technology is the most widely used technology in North America and around the world, as it does not require advanced front-end processing of the MSW feedstock.

With many facilities operating 25 to 40 years, direct combustion is the most widely demonstrated and commercially viable of the thermal conversion technologies available. Since the mid-1970’s the direct combustion industry has improved efficiency through new boiler designs and equipment upgrades and also reduced emissions through modern APC equipment and other operational techniques.

**Pros:** This is a proven technology, has a history of successful operation in the county and in commercial operations at more than 70 facilities in the U.S., six in Canada, 450 in Europe and over 500 in Asia. Mass burn facilities are a flexible technology in terms of processing variable waste streams. It yields an approximate 90 percent reduction in volume resulting in significant savings in landfill space. Development of the technology can create a number of construction jobs over the one to three years of construction and 40 to 80 permanent jobs over the life of the project.

**Cons:** This technology generally requires a large waste stream to be economically beneficial. Although the technology recycles and re-uses water on-site, it requires a moderate use of make-up water. Permitting of WTE facilities is typically a multi-year effort. Recently, Frederick County Maryland applied for a permit in February 2011 and the Final Determination was issued in February 2014. The permit was revoked in January 2015 at the request of the applicant.

**Cost – HIGH.** The 500 tpd Durham York WTE Facility in Ontario Canada, operational in 2016, had a total capital construction cost of $245,000,000.

### 4.1.2 Gasification

Gasification has been used for over two hundred years starting with coal gas in the 1790s used for factory lighting. During World War II, gasification of wood was used by Germany to synthesize fuels for vehicles and aircraft. Starting in the 1970s to the present-day, the fuel gas produced from the gasification of various types of biomass (i.e., wood and woody wastes) has been used on a smaller scale to fire stationary internal combustion engines, or as a building block to produce liquid fuels. Some modular combustors operate on the principles of gasification through a two-stage combustion process (similar to the Harford County WTE Facility) in which the first chamber operates in a low-oxygen or starved air environment and the combustion is completed in the second chamber.

Gasification technologies convert carbonaceous material (such as MSW) into a raw gas that is called producer gas that contains principally CO, hydrogen (H₂), methane (CH₄), and other light hydrocarbons, as well as CO₂ and nitrogen (N₂), depending on the specific process. The fuel or synthesis gas (syngas) is primarily CO and H₂ and is derived from the producer gas through appropriate cleaning and reforming processes. The relative concentration of syngas components depends upon the composition of the feedstock and process operating conditions (autothermal, allothermal, air, oxygen, or steam injection, temperature, pressure, etc.). Syngas can be used as a fuel to generate electricity directly in a combustion turbine or
internal combustion engine, or more likely fired in a heat recovery steam generator (HRSG) to create steam that can be used to generate electricity through a steam condensing turbine as in the WTE technology described above. The syngas generated can also theoretically be used as a chemical building block in the synthesis of liquid fuels. Figure 4.1 shows an example of a 250 tpd gasification facility in Fukuoka, Japan (Homan Gasification Plant).

There are a wide variety of technology designs that can be defined as gasification. Many gasification technologies are sensitive to the type and quality of materials they process, so the feedstock for most of these technologies must be prepared from the “raw” incoming MSW through shredding and pre-sorting to pull out bulky materials and other materials, such as dirt, glass/grit, and metals that may cause operating issues in the gasification unit.

Gasification facilities that combust the syngas generated by the process will have similar air emissions as traditional WTE facilities. However, the volume and concentration of these air pollutants should theoretically be lower. If the syngas is conditioned for use elsewhere (e.g. as part of a catalytic process to generate a liquid fuel), then additional gas cleaning and conditioning equipment is required. These technologies also produce small amounts of char or ash in quantities similar to tradition WTE technologies, or less (<90 percent by volume and <20 percent by weight). Other metals and inert materials can remain with the char/ash and may be recovered after processing.

![Figure 4.1 Photo of the 250 TPD Homan gasification plant in Fukuoka, Japan](source: HDR Photo)

There are no known gasification facilities operating in North America which utilize a mixed MSW waste stream as a feedstock to the process. However, in Asia and Japan there are several commercial-scale gasification facilities, some of which have been operating almost two decades. These facilities are known to process feedstock materials using units sized from about 100 tpd to 275 tpd which are usually combined in multi-unit configurations, to create a facility with an overall capacity of 500 tpd or greater. Some gasification facilities in Japan utilize feedstocks with high-energy content, such as industrial wastes, or a
combination of these feedstocks and MSW. The drivers for the use of gasification in Japan are largely related to the lack of available landfill capacity and very stringent emission standards, which favor the use of this technology. In addition, it is important to understand that waste tipping fees in Japan are much higher than the U.S. (in excess of $250/ton), which makes these facilities financially viable. In Japan, one goal of the process is to generate a stabilized, and in some cases vitrified, ash product that can be beneficially reused as an aggregate in the construction industry, thus limiting the amount of material having to be diverted to scarce Japanese landfills. However, the use and marketability of this material in the United States is unknown.

Thermal gasification of MSW in the United States has been attempted for many years, but many of these facilities experienced difficulties with scaling-up to commercial operations. Currently, gasification technologies in North America are mostly limited to demonstration or pilot-scale operations with limited operational history. This is partially due to economics of low electricity prices and lower landfill tipping fees in the United States. It is also due to the costs and difficulty associated with front-end processing of MSW to achieve a homogenized and higher BTU-content MSW feedstock suitable for some gasification technologies. In addition, many of the gasification facilities are having issues meeting the gas quality and energy content of the syngas required to allow the engines or other power operating equipment to efficiently produce electricity. Facilities built on a larger scale, such as Covanta Energy’s CLEERGAS® facility in Oklahoma, are using a variation of gasification, which is essentially a two-stage combustion process, where materials are gasified in the first chamber and the gas is immediately combusted in the second chamber, with no actual syngas being produced for external use. This technology is closer to direct combustion technology than gasification, but has shown promise as a potentially commercially viable gasification technology option. In addition, the CLEERGAS technology is marketed as an affordable option for communities that produce waste in the 300-tpd range.

**Pros:** Gasification operators assert one of the benefits of gasification is that very high diversion levels (above 90 percent by volume) can be achieved because the slag is not leachable and can be sold as aggregate to industrial users. In addition, the emissions from gasification technologies are lower than that from direct combustion. However, to date, actual emissions from operating facilities are difficult to obtain or verify due to the lack of commercial-scale facilities in North America. Other benefits include the production of energy, or a liquid fuel if the syngas produced is further cleaned and passed through a catalytic process (e.g. Fischer-Tropsch). Local benefits include the creation of construction jobs over the one to three year construction period and 25 to 75 permanent jobs over the life of the project.

**Cons:** Although there are some commercial-scale facilities in Europe and Asia, there has been limited commercial application using mixed MSW in North America. The technology may only efficiently process a specific subset of waste materials (not mixed MSW as reviewed in this document) such as wood waste, tires, carpet, scrap plastic, or other homogeneous waste streams.

**Cost – HIGH.** Preparation of a homogenous RDF remains one of the most difficult tasks. It involves a large amount of mechanical processing and close supervision, which greatly impact operating costs and can account for as much as 40 percent of the total plant capital costs. The capital cost of the 220 tpd Thermiska TPS plant in Italy was approximately $170M.
with the RDF plant making up about $63M (37 percent) of that cost. Operation and maintenance costs for the Thermiska plant was estimated at $36/ton.

### 4.1.3 Plasma Arc Gasification

PAG is considered a subset of thermal gasification. Plasma arc melting technology has been used in the metal industry since the late 19th century. PAG has been used more recently as a disposal option for a range of industrial and other disposal applications, such as the gasification of hazardous wastes, auto shredder fluff, and other types of more homogeneous wastes. Only within the last 10 to 15 years has this technology seen interest as a possible source of disposal and conversion of an MSW feed stock, and this has mostly occurred at smaller-scale demonstration and pilot-scale plants.

PAG technologies typically use carbon electrodes to produce a very-high-temperature arc ranging between 5,000 to 12,000 degrees Fahrenheit that vaporizes the feedstock. The high-energy electric arc that is struck between the two carbon electrodes creates a high temperature ionized gas (or plasma). The intense heat of the plasma breaks the MSW and the other organic materials fed to the reaction chamber into basic elemental compounds. As the feedstock gasifies, a low-BTU syngas is generated similar to other gasification technologies. In theory, the high temperatures produced by a PAG technology produces a cleaner and higher quality syngas than other technologies that can be more easily cleaned and combusted directly in an internal combustion engine or gas turbine to produce electricity and/or thermal energy (i.e., steam, hot water). The inorganic fractions (glass, metals, etc.) of the MSW stream in a PAG system are melted to form a liquid slag material which vitrifies when cooled to encapsulate toxic metals. Recyclable metals can also be recovered from both feedstock pre-processing and from post-processing the slag material.

Similar to some other gasification processes, the MSW feedstock delivered will need some pre-processing to shred and homogenize the size of the feedstocks, as well as to minimize materials that may cause potential operating issues. Vendors of this technology claim the energy efficiencies capable with PAG systems are higher than Direct Combustion and other gasification technologies. These higher efficiencies are theoretically possible if a combined cycle power system is proposed to harness the energy in the syngas; however, this has not been proven for PAG systems on a commercial-scale. The plasma vendors of this technology claim to achieve lower concentrations of emissions than more conventional technologies, like Direct Combustion. However, air pollution control equipment similar to other thermal technologies is still required to clean the gas from the combustion of the syngas as these facilities generally have similar air emissions issues as other Gasification, Pyrolysis and Direct Combustion facilities. Mercury and some other more volatile metals are expected to be driven off with the gas and will need to be removed from the exhaust of the gas combustion device.

Outside the United States, start-up and commissioning of a large, approximately 1,000 tpd, plasma gasification facility in Tees Valley in the United Kingdom was halted last year. Individual units in Japan, and around the world, are sized anywhere from about 20 tpd to 200 tpd, and are sometimes combined in multi-unit configurations when developing a facility to create an overall capacity of 400 tpd or greater. Although Japan has about 10 to 15 years of operating experience, their facilities are mainly used for ash melting (as described below) or used for industrial waste or MSW with high plastics content that increases the BTU value. Several facilities operate in Japan, most notably three developed by Hitachi Metals, in
Yoshii, Utashinai, and Mihama-Mikata. These facilities are referred to as plasma direct melting reactors. The name is significant due to the desire in Japan to vitrify ash from mass burn WTE facilities.

Many gasification facilities in Japan also accept ash from conventional WTE facilities for vitrification. The facilities are, in many cases, intended as ash vitrification facilities rather than energy recovery facilities. The benefit of the vitrified ash is to bind potentially hazardous elements thereby rendering the ash inert. In Japan most facilities use this vitrified ash as an aggregate product. Because of the high MSW tipping fees and other economic drivers in Japan, and the fact that the PAG facilities only operate about 9 months per year makes any data from these facilities difficult to correlate to conditions in the United States.

Attempts to develop plasma gasification facilities in the United States have met financial hurdles. In April 2012, after five years of planning, construction of a large scale PAG facility in Saint Lucie County, Florida was cancelled. The NRG/Adaptive Arc was in the permitting/approvals phase for a facility in Atlantic County, NJ but was eventually canceled. A demonstration project located in Ottawa, Ontario, Canada (i.e., the 110-tpd Plasco Trail Road Facility) also utilized the principles of PAG on a mixed MSW waste stream. However, after almost eight years of sporadic operations and design issues, the facility ultimately closed due to funding issues. However, there are still some demonstration facilities in North America that utilize PAG technology, such as the Westinghouse Plasma demonstration facility in Madison, Pennsylvania. There is also a 10-tpd demonstration PAG unit (manufactured by Pyrogenesis based out of Quebec, Canada) that is being used on a mixed MSW waste stream at Hurlburt Field Air Force Base in Florida. This facility has been in some form of operations and testing since 2010, but is used more as a testing facility for scale-up of the technology. Pyrogenesis has also made PAG waste processing systems for onboard ship waste for U.S. Navy and commercial surface vessels. S4 Energy Solutions, a joint venture of Waste Management, Inc. and a subsidiary to InEnTec Inc. has built a small 25 tpd facility at the Columbia Ridge Landfill in Arlington, Oregon. It started accepting waste in late 2011, and has produced a syngas, but is still in the testing stages to successfully process the full 25 tpd and produce the gas products planned. Currently, however, no commercial operating facilities using MSW as a feedstock exist in the U.S.

**Pros:** Benefits include a claimed over 95 percent diversion of waste from landfills, production of energy and potential uses of the by-products of ferrous metals and the slag formed and marketed as aggregate (although no markets currently exist for this product). This technology can produce lower emissions than traditional mass burn technology and yield volume reductions similar to mass burn (~90 percent). PAG is operated on a commercial scale using select waste streams in Europe and Asia so it is considered a somewhat proven technology and has a higher energy recovery efficiency that traditional mass burn and conventional gasification. A local benefit is the creation of construction jobs over the one to three years of construction and 25 to 60 permanent jobs over the life of the project.

**Cons:** Although there are some commercial-scale facilities operating on relatively low tonnages of sorted MSW in Europe and Asia, there has been very limited commercial application using mixed MSW in North America. It should be noted that although the technology recycles and re-uses water on-site, it requires a moderate amount of make-up water.
Cost – HIGH. One unit of the Tees Valley Plasma Gasification Facility in the United Kingdom had a total capital investment of $500,000,000; and the cost for two units was over $1 billion.

4.1.4 Pyrolysis

Pyrolysis technologies are closely related to gasification and some facilities can fall into either technology category depending on how they are operated. Pyrolysis is defined as the process of heating material to high temperatures (700° to 1,500°F) in the absence of oxygen to produce a combustible gas and a liquid product (or pyrolytic oil) and a carbon-rich solid residue. This is similar to what is done to produce coke from coal or charcoal from wood. The feedstock is typically homogeneous such as coal or biomass, and there is some applicability to using waste tires as a feedstock. However, the entire municipal waste stream is used in some operations after pre-processing to obtain a homogeneous feedstock (similar to RDF). Similar to gasification, the Pyrolysis process is designed to optimize the production of gases or liquids. Syngas is produced and used as fuel in boilers with HRSGs, or in internal combustion units or gas turbines, provided that the syngas is adequately cleaned. As discussed, the pyrolysis process is performed in an air- or oxygen-free environment, and therefore the system typically has a complex design and control system to prevent air or oxygen from intruding into the process, or the system is designed to purge air from the reaction chamber. Some pyrolysis processes do allow very small amounts of air/oxygen into the system to allow the feedstock to partially combust to help sustain the heating process.

Similar to gasification technologies, the air emissions generated from pyrolysis systems are primarily those created from the combustion of the syngas produced (and possibly char); for example, in an internal combustion engine-generator set or directly in a boiler. The cleanup and treatment of syngas produced from pyrolytic processing of MSW for use in engines or combustion turbines has little long-term operating history in North America. Pyrolysis technologies also produce a pyrolytic oil that, depending on the quality and costs to refine, could be used as bunker fuel for generating heat to sustain the process, or for other onsite purposes. Other pollutants in quantities similar to gasification technologies would be expected as a result of combusting the gas or oil produced from the process. These emissions can be controlled using modern air pollution control devices to meet local, state and national regulatory standards. A solid char material would also be produced that would likely require disposal in a landfill.

Pyrolysis systems have had some historical operating success with woody biomass feedstocks and specific waste components such as shredded used tires; however, there is no known long-term commercial success with using MSW as a feedstock in these technologies. Historically, a few large-scale pyrolysis facilities were built in the United States that had mechanical and other scale-up problems when processing MSW. Of particular note were large-scale pyrolysis plants built near Baltimore and San Diego in the 1980s that were scaled up from pilot projects and never able to function at a commercial level. Several other projects were also completed, but none have proven to be economically viable. In Germany, at least one pyrolysis facility using MSW as a feedstock is operating. It was built in the mid-1980s and appears to still be operating today. It is a relatively low capacity facility and was not replicated on a larger scale. A plant in Moscow is being built to demonstrate use of MSW as a feedstock. Agilyx, based in Beaverton, Oregon is currently operating a type of pyrolysis technology that utilizes chemical and thermal processes to heat plastic wastes and break it down to short-chain hydrocarbons and eventually synthetic crude oil.
**Pros:** Benefits include a claim of over 90 percent diversion of waste from landfills, the production of energy and potential uses of the by-products, if marketable. Other local benefits include the creation of construction jobs over the one to three years of construction and a certain amount of permanent jobs over the life of the project.

**Cons:** Pyrolysis of MSW has limited long-term operational history and no commercial success in North America to date. There is little reliable information regarding long-term operating experience or costs associated with this technology.

**Cost – MEDIUM.** According to a 2013 Department for Environment, Food & Rural Affairs (DEFRA) study from the United Kingdom, capital cost provided by pyrolysis (and other thermal technology) suppliers and capital cost reported in the trade press have a wide range. For a 100,000 tpy facility a capital cost of £55M ($83M) was cited with the warning that “extreme care is required in utilizing cost data as it might not be fully inclusive.”

### 4.2 Biological Technologies

#### 4.2.1 Aerobic Composting

Aerobic composting is typically used with source-separated yard waste, similar to the Complex’s operation, in which windrows are maintained at a minimum 130°F temperature with proper moisture and aeration for 45 days. Aerobic composting can include a number of different processes; however, the two most common are aerobic windrow composting and forced aerated static pile composting. Windrow style composting is typically conducted outdoors, while forced aerated static pile composting is typically performed indoors. However, some forced aerated static pile composting is conducted outdoors in areas that are isolated from odor receptors or with systems that use a bag system to contain the materials (see Figure 4.2).

![Figure 4.2 Example of an aerobic composting facility – forced aerated static pile](image)

In windrow composting, the materials (generally green material) are placed in elongated piles called windrows that are aerated naturally through a chimney effect, mechanically by physically turning the windrows with a machine, or the windrows are pierced with lances to improve porosity and promote aeration. Frequent turning of the pile introduces oxygen, accelerates physical degradation of feedstocks, and provides an opportunity to adjust the moisture content to the optimum level. This technology is particularly odorous if food waste
is included in the feedstock. The average time required for active aerated composting is eight to 12 weeks. Figure 4.3 shows an example of aerobic composting using an outdoor windrow system.

In an enclosed forced aerated static pile composting technology, fresh air is forced into the pile to speed up the process and to ensure that the system remains aerobic. This method is suited to producing large volumes of compost in relatively smaller areas. This technology is particularly odorous if the composting pile is allowed to have pockets of anaerobic activity. The aerated composting process refers to any of a number of systems used to biodegrade organic material without physical manipulation during primary composting. The blended mixture is typically placed on perforated piping, providing air circulation for controlled aeration. It may be in windrows, open or covered, or in closed containers (in-vessel). In most facilities using the aerated compost process, a series of perforated pipes draws air down through the windrows to an air collection manifold that runs under the windrows. The compost-air is drawn through the compost using a blower system which then pushes the air through a biofilter that acts as an emission and odor control system. Alternatively, air is injected into the windows; however, this results in dispersing the potentially odorous air and therefore is not recommended.

Aerobic composting is used by numerous communities in commercial operations throughout the United States and the world for composting yard and green wastes; however, it is not typically used for a mixed MSW feedstock. Although windrow composting is the most popular, aerated static pile composting is used quite frequently. Products from aerobic composting are compost and mulch. Aerobic composting projects are sized as low as only a few tons per day to more than 500 tpd. An aerobic composting facility of 250 tpd to 400 tpd is typical.

![Figure 4.3 Example of a windrow aerobic composting facility](image)

**Pros:** Benefits of aerobic composting include diversion of organic wastes from landfill and the local production of compost and mulch which can be used within the community. There are commercially-operating plants in parts of Europe and some development in the United
States operating on source separated organics or the organic fraction of MSW. Local benefits include the creation of construction jobs over the short period of construction and about two to 10 permanent jobs over the life of the project, depending on the size and complexity of the facility.

**Cons:** Potential for high operating costs. Only the organic fraction of total MSW stream can be processed leading to a high residual waste generation (up to 40 percent of incoming waste stream). There is a real potential to create odors, noise, and dust; however, this can be mitigated with proper operations and facility siting.

**Cost – MEDIUM.** Capital costs for aerobic composting varies by type. For a 60,000 tpy facility the estimated capital cost for windrow, aerated static pile, enclosed channel, and container/tunnel are $5.4M, $10.8M, $21.6M, and $39.6M, respectively. Operating cost per ton range from $33 to $53.

4.2.2 Anaerobic Digestion

Anaerobic digestion (AD) is commonly used to treat wastewater biosolids; however, it has also been used as a way of treating some organic portions of the MSW waste stream. These processes were first employed in the 1980s under the term MBT. A few facilities were developed in the United States using these AD and MBT technologies; however, for the most part, these facilities ceased to operate years ago due to a variety of issues. However, evolution of the technology in Europe has re-introduced North America to the benefits of anaerobic digestion in combination with aerobic composting to bio-stabilize the process residue. AD and MBT are successfully operating in Europe due to landfill ban policies, high tipping fees and high prices paid for energy.

The AD process occurs when organic matter is decomposed using bacteria in the absence of oxygen. By consuming the organic materials, the bacteria produce a biogas (primarily methane and carbon dioxide). Feedstock for AD vary according to the type of technology but in broad terms can include MSW-derived organics, manure, food waste, grass clippings, and for some technologies, yard waste, brush and wastewater treatment plant biosolids. Biologically inert materials present in the digestion feedstock, such as metals, glass, and plastics, are undesirable and considered contamination and must either be removed prior to digestion (for wet type systems) or be screened-out during or after digestion (for dry type systems).

There are several factors that influence the design and performance of AD. Some of these factors include: the concentration and composition of nutrients in the feedstock, temperature of the digesting mass, and retention time of the material in the reactor, pH, acid concentration, and oxygen level.

AD can be categorized into two types of processes:

- Wet systems that require the feedstock to be prepared into liquid slurry and whose process is liquid in a tank or similar type of container. Wet systems can be treated in either of the following levels of solids:
  - High-solids: between 15 and 40 percent solids in a liquid slurry or paste
  - Low-solids: typically, less than 15 percent solids.
Dry systems, are often referred to as dry fermentation, and unlike wet systems, dry fermentation systems do not prepare or pre-process the feedstock; instead the feedstock is retained in a stacked pile as a stationary solid, with circulating bacteria rich liquid through the solids to perform the degradation process. Dry systems process the feedstock as a solid, and typically operate as a batch type process in bunkers or storage type containers.

Since mid-2013, JC-Biomethane has operated a $16M, 60-80 tpd wet-type anaerobic digestion facility located in Junction City, Oregon. This facility, as shown in Figure 4.4, uses a conventional stir tank reactor (CSTR) design for the digestion. It accepts commercial organics, such as food waste and agricultural residues to produce approximately 1.5 MW of power from 450 cfm of digester gas. This facility relies on post-consumer food waste from commercial sources to make up 80 percent of the feedstock; less than 5 percent of the feedstock comes from fats, oil & grease (FOG) and manure. It does not accept residential food wastes.

![Figure 4.4 Photo of JC-Biomethane's anaerobic digestion facility in Junction City, Oregon](source: Courtesy of Register-Guard News)

Bunker-type dry fermentation facilities consist of a series of concrete bunkers equipped with air tight ceilings and doors, as shown in Figure 4.5.
The most conventional use of the biogas produced from any AD process is as a fuel in internal combustion engines and gas turbines to produce electricity. A by-product of the process is a digestate which can be processed into a compost or mulch.

AD is widely used on a commercial-scale for industrial and agricultural wastes, as well as wastewater sludge. AD technology has been applied on a larger scale in Europe on mixed MSW and source separated organics (SSO), but there is limited commercial-scale application in North America. The Greater Toronto Area is home to two commercial-scale plants that are designed specifically for processing SSO; the Dufferin Organic Processing Facility and the Newmarket AD Facility.

There are a growing number of AD facilities in the United States operating on mixed MSW, SSO, and/or co-digested organic wastes with wastewater biosolids.

**Pros:** Benefits of this technology include diversion of organic waste from landfill, the production of energy and potential uses of the by-products. There are commercially operating plants in Europe and a fledgling industry in the United States operating on source-separated organics and some on the organic fraction of MSW. It may be possible to retrofit existing wastewater treatment plant digesters to accept the organic fraction of MSW. Local benefits include the creation of construction jobs over the year or so of construction and about 10 to 25 permanent jobs over the life of the project, depending on the size and complexity of the facility.

**Cons:** Requires a high level of pre-processing to remove inorganics from the MSW stream (metals, glass, and inerts) and reduce the size of organics prior to digestion. There is high residual waste generation (up to 40 percent of waste stream) as only the organic fraction of the waste stream can be processed. Successful projects use a limited waste feed stream of source separated organics (food waste from grocery stores and restaurants) and wastewater
treatment plant biosolids. There is a potential for high capital and operating costs. There is a potential for creating odors, noise and dust.

**Cost – VARIES.** Capital costs for a recent 180 tpd facility in Maine were approximately $10M. However, a mixed waste (MW) anaerobic digester, that can accept MSW, ranges from $250 to $650 per ton of design capacity. Operation and maintenance cost (including annualized capital cost) range from $45 per ton to $65 per ton.

### 4.2.3 Mechanical Biological Treatment

MBT is a variation on composting and materials recovery that incorporates a two-stage process of mechanical and biological treatments. The technology is used widely in Europe (particularly in the UK, Germany, Italy and Spain), and sparingly in other places around the world (for example in Australia). There is also an MBT facility in operation in Halifax, Nova Scotia, Canada.

During the mechanical stage of the MBT process, the entire feedstock is sorted to remove recyclables and contaminants and then shredded or grinded for size reduction prior to the biological stage. The biological stage includes a digestion step in an enclosed vessel which produces a bio-gas that is used to produce energy in addition to heat to dry the feedstock, thereby making it ready for processing into an RDF product as described below. If no fuel markets are available, the product could be further composted to render the material inert for landfilling.

This technology is designed to process a fully mixed MSW stream and can handle the County’s waste stream. Materials usually derived from the process include marketable metals, glass, and other recyclables. Limited composting is used to break the MSW down and dry the fuel. The order of mechanical separating, shredding, and composting can vary. It is an effective waste-management method and can be built in various sizes, but there is often a significant quantity or residue material remaining (up to as much as 50 percent of the incoming waste stream) that must be processed or disposed of in some manner. Some of this residue material is used in an RDF that is fed/sold as a fuel for some thermal process (e.g., combustion, gasification, etc.). It is also used as a fuel by other industries, such as cement kilns. Consequently, similar to RDF, the MBT process produces a fuel product that depends on the sale of the product for economic viability.

**Pros:** The post-collection separation of feedstock will divert materials from landfills while preparing a feedstock for digestion and thermal consumption. The technology is used in Europe, including Herhof GmbH facilities in Germany, and there are several operating plants in Korea, Spain, Eastern Europe and the UK. Recently, Wrexhan of Greater Manchester has signed an agreement to have a large MBT developed for their area. A local benefit is the creation of construction jobs over the construction period and approximately 10 to 50 permanent jobs over the life of the project.

**Cons:** Although used in Europe, there has been no commercial development of MBT in the United States using an MSW feedstock. There is still a large residual stream left over from the technology that must either be further processed (e.g., by a thermal conversion technology) or landfilled. The technology relies heavily upon the sale of the by-products and fuel produced for its sustainable economic viability. Other operating drawbacks include the
potential for creating odors, noise and dust; however, some of these can be mitigated with proper operations and facility siting.

**Cost – VARIES.** According to a 2015 WasteAdvantage article, “Capital costs for MBT facilities are relatively high.” That said, capital cost will vary depending on the type of biological treatment that follows the mechanical separation and with the type of end use product selected for the residuals. Average capital cost for a 50,000+ tpy facility with aerobic composting range from $50 to $380 per ton of annual capacity. The same sized facility with an anaerobic digester will range from $180 to $470 per ton of annual capacity. The aforementioned article also reported that, “Operational costs at German MBT plants have been reported in the range of $45 to $103 per ton of MSW processed.”

### 4.3 Chemical Technologies

#### 4.3.1 Hydrolysis

There is much interest and development in the area of cellulosic ethanol technology to move from corn-based ethanol production to the use of more abundant cellulosic materials. Hydrolysis is part of that development. The hydrolysis process involves the reaction of the water and cellulose fractions in a feedstock (e.g., paper, yard waste, etc.) with a strong acid (e.g., sulfuric acid) to produce sugars. In the next process step, these sugars are fermented to produce an organic alcohol. This alcohol is then distilled to produce a fuel-grade ethanol solution which can be burned in energy conversion devices such as heaters and engines.

Hydrolysis is a multi-step process that includes four major steps: pre-treatment; hydrolysis; fermentation; and distillation. For an MSW feedstock the pre-treatment step amounts to removal of any inorganic/inert materials (glass, plastic, metal, etc.) from the organic materials (yard waste, paper, etc.). Feedstock materials that are appropriate for hydrolysis/fermentation of the cellulosic components of MSW include wood, green waste and paper. This process does not handle or convert MSW directly and is best suited for clean source-separated cellulosic waste components. The organic material is shredded to reduce the size and to make the feedstock more homogenous. The hydrolysis step places the shredded organic material into a reactor where it is introduced to the acid catalyst, with the cellulose in the organic material converted into simple sugars as discussed above. The fermentation step utilizes these sugars to be fermented and converted into an organic alcohol. The distillation step takes the organic alcohol and distills it into fuel-grade ethanol. The by-products from this process are carbon dioxide (from the fermentation step), gypsum (from the hydrolysis step) and lignin (non-cellulose material from the hydrolysis step). Since the acid acts only as a catalyst, it can usually be extracted and recycled back into the process.

The process of chemical hydrolysis is well established for some organic feedstocks, such as in the conversion of wood to paper pulp, but has only been applied to MSW-derived organics on a conceptual basis, or limited to laboratory- or pilot-scale.

**Pros:** Benefits include the diversion of organic waste from landfill and the production of a cellulosic ethanol that can be used as a fuel product. A local benefit is the creation of construction jobs over the construction period and a certain amount of permanent jobs over the life of the project; however, this figure cannot be estimated as the technology requires additional development.
Cons: There is no widespread commercial application of this technology using MSW as a feedstock in North America or abroad. Similarly, the environmental risks are not well defined. There are some emissions risks related to methane emissions and potential issues dealing with potential chemical spills. It is also expected that significant quantities of water will be required.

Costs – UNKNOWN. The current hydrolysis projects concentrate on primarily wood waste as opposed to a municipal waste, no cost information is available that would be of relevant to this report.

4.3.2 Catalytic and Thermal Depolymerization

The depolymerization, or cracking, process converts long-chain hydrocarbon polymers present in some waste materials into intermediate products that can be processed into fuels such as diesel and gasoline. Pressure and heat are used to decompose long-chain polymers composed of hydrogen, oxygen, and carbon into shorter chains of petroleum-like feedstock. This process is somewhat similar to that used at an oil refinery to convert crude oil into usable products, including the use of distillation to segregate the desired hydrocarbon liquids (such as diesel fuel). The typical feedstocks proposed for depolymerization are plastics, FOG, and offal (i.e., processed animal soft tissue). There are two depolymerization methods that can be used to convert organic materials into fuel: thermal and catalytic.

THERMAL DEPOLYMERIZATION

Thermal depolymerization utilizes temperature (ranging from 1,000° to 1,400° F) and pressure to crack the large hydrocarbon molecules within the feedstock. Once the hydrocarbon molecules are broken into shorter chains, additional refining steps are required to convert the molecules into oil. The high temperature and additional refining steps in the thermal process require the input of a significant amount of energy, as compared to the catalytic depolymerization approach. The energy balance data for thermal depolymerization of waste-derived organic materials are lacking with regard to commercial scale processing.

CATALYTIC DEPOLYMERIZATION

The catalytic depolymerization process uses lower temperatures (ranging from 500° to 700°F) and lower pressures than thermal depolymerization. In order to achieve adequate product yields and qualities at the lower temperatures and pressures, a catalyst is employed to aid in the process of breaking down or cracking the large molecules efficiently. Zeolite, silica-alumina, and bauxite are common types of catalysts used in the process. In a catalytic depolymerization process, the plastics, synthetic-fiber components and water in the feedstock react with a catalyst under non-atmospheric pressure and temperatures to produce a crude oil. This crude oil can then be distilled to produce a synthetic gasoline or fuel-grade diesel.

There are four major steps in a catalytic depolymerization process: pre-processing, process fluid upgrading, catalytic reaction, and separation and distillation. The pre-processing step is where the feedstock is removed of contaminants and is sized. This process typically requires processing to produce a much smaller particle size with less contamination. The next step in the process is preparing this feedstock. The feedstock is mixed with water and a carrier oil (hydraulic oil) to create a sludge-type material. This sludge is sent through a catalytic turbine where the catalytic reaction under high temperature and pressure produces light oil. The light oil is then distilled to separate the synthetic gasoline or diesel oil. This catalytic depolymerization process is somewhat similar to that used at an oil refinery to convert crude
oil into usable products. This technology is reportedly most effective with processing a waste stream with high plastics content and may not be suitable for a mixed MSW stream. The need for a high-plastics-content feedstock also limits the size of the facility.

One vendor claims to have a commercial-scale facility in Spain that has been in operation using MSW since late 2009; however, operating data (including feedstock used) could not be obtained and verified. Catalytic depolymerization has been proposed in some locations for select portions of the waste stream with concentrated plastics content. It might be most effectively applied at a very large plastics manufacturing facility or similar industry that can become the source of the feedstock. Because such arrangements are very rare, limited interest in this technology has developed.

**Pros:** Benefits include the diversion of plastic and oil waste from landfills, the production of an oil or fuel product that can be used as fuel. A local benefit is the creation of construction jobs over the construction period and a certain amount of permanent jobs over the life of the project. This figure cannot be estimated as the technology requires additional development.

**Cons:** The technology can theoretically use MSW and biomass as feedstocks, but this has not been shown as feasible except at extremely small scale. There are no large-scale commercial thermal or catalytic depolymerization facilities operating in North America that use a purely mixed MSW stream as a feedstock. There are some facilities in Europe and one in Mexico that utilize this or a similar process to convert waste plastics, waste oils, and other select feedstocks. The environmental risks are not well defined. Catalytic cracking could emit some hydrocarbons from the process. There could also be some other risks resulting from the handling of the catalysts or solvents and related compounds that might be required for the process. Water use and wastewater generation is also not known.

**Cost – UNKNOWN.** At this time, the capital and operation and maintenance cost for these technologies is either not available or is highly variable to the point of being unreliable.

### 4.4 Waste-to-Fuel Technology

The generation of liquid fuels from wastes is an evolving technology. Waste-to-fuel technologies typically involve four main steps: pre-processing and preparation of the feedstock material (e.g., woody biomass or MSW); converting the feedstock to generate a syngas through some thermal conversion process (e.g., gasification or another technology); cleaning and conditioning the syngas of impurities and other contaminants; and passing the syngas through a catalytic process to synthesize a liquid fuel. The use of woody biomass and some agricultural wastes as a feedstock for these technologies has some long-term operating track record. There are also some demonstration/pilot projects that are attempting to use MSW or other feedstocks that are described in more detail below. However, the long-term operating and financial viability of using an MSW feedstock to produce a liquid fuel is still unknown.

There are several proposed methodologies to convert MSW into fuels. The first step that the majority of MSW-to-fuel technologies share requires the use of a process to generate a syngas, typically a thermal conversion process such as gasification. The next and most important step in this process is to take the syngas produced and clean it to remove impurities (tars, hydrocarbons, contaminants, etc.) that can impact the catalytic process. The next step involves a catalytic process, such as a Fischer-Tropsch (FT) process, that is
needed to convert the syngas into a liquid fuel. The FT process is defined as a collection of chemical reactions that use a metal-based catalyst (cobalt, iron, or others) to convert a mixture of carbon monoxide and hydrogen into liquid hydrocarbons. The FT process has been around for almost 100 years, and is most commonly used to convert coal, biomass or even methane into synthetic liquid fuels. The purity of the syngas used can be critical in the success of the FT process, which makes syngas produced from MSW gasification challenging because of the contaminants present in the MSW feedstock and the relatively low ratios of H₂ to CO.

As described, FT is one of the most popular types of a chemical catalytic process used to synthesize the syngas into a liquid fuel. In addition to the FT synthesis, there is methanol synthesis; mixed alcohol synthesis; or syngas fermentation. Each process features different reaction pressures and temperatures, requires different syngas compositions, and uses different catalysts.

Feedstock preparation, gasification, syngas clean-up and fuel synthesis are commercially viable at some scale using select feedstock materials such as biomass, coal or petroleum based materials. However, when using MSW as a feedstock, these systems as a whole are still in the development or demonstration stage. One example of commercial-scale waste-to-fuel technologies in commercial development is the Enerkem facility in Edmonton, Alberta, Canada. In June 2014, Enerkem Alberta Biofuels opened a 10 million gallons per year methanol facility that will help Edmonton reach a 90 percent MSW diversion goal by accepting up to 100,000 metric tons of MSW (the city already diverts 60 percent of the MSW stream). Enerkem utilizes an MSW gasification-to-liquid fuels technology that utilizes an FT-type catalytic process to generate the liquid methanol. The Enerkem facility in Edmonton is currently in operation. Figure 4.6 shows a picture of the facility.

Another biofuels facility, the Ineos Biofuels waste-to-fuel technology facility located in Vero Beach, Florida has been shut down. This 300-tpd improved radial basis function (IRBF) (two units at 150 tpd/each) cost approximately $130 million and started operations in late 2012 using woody biomass wastes as a feedstock. The technology used a thermal gasification process to generate a syngas that is then passed through a fermentation reactor where biological organisms convert the hydrogen and CO in the syngas directly to ethanol. The IBRF had operational issues and challenges from startup and was shuttered in 2017.

**Pros:** Benefits include the potential production of an ethanol-based fuel. A local benefit is the creation of construction jobs over the construction period and a certain amount of permanent jobs over the life of the project.

**Cons:** There is minimal long-term operations and cost information available on this technology with using MSW as a feedstock. The largest drawbacks include the costs associated with processing and refining the MSW feedstock to meet the technology requirements, as well as the costs associated with the syngas cleaning/refining technologies. Furthermore, the current energy and fuels markets bring the financial viability of producing a fuel into question.

**Cost – HIGH.** The capital cost for the Enerkem facility described above was approximately $100,000,000; the pre-processing facility capital cost was approximately $40,000,000 (owned and operated by the City of Edmonton). Enerkem receives $45 per ton from the City...
of Edmonton to accept their pre-processed MSW. Enerkem expects to make $1.50 per gallon for the ethanol produced.

![Enerkem's waste-to-fuels project in Edmonton, Canada](image)

Source: Picture courtesy of Enerkem

### 4.5 Mechanical Technologies

#### 4.5.1 Mixed Waste Processing Facilities

There are two general type of MWPFs currently operating in the United States; those that accept source-separated recyclables (formerly called clean material recovery facilities, or MRFs), and those that accept mixed MSW and process these materials to recover recyclables and reusable materials leaving the residual waste for landfilling or another appropriate waste processing application (formerly called dirty MRFs).

To help combat low public participation rates of traditional recycling programs such as curbside single-stream and source separated collection of recyclables, some communities are turning to MWPF to either capture recyclables for processing and sale or as a pre-sorting operation prior to more advance conversion technologies. The MWPF process begins with mixed solid waste from residential and/or commercial collection vehicles being off-loaded onto a tip floor. Materials are first sorted on the floor using manual labor and mobile equipment to remove larger or bulky items such as appliances, dimensional wood, metal, or large pieces of plastics that might clog or interrupt operations of the advanced processing systems.

Material is then processed through multi-stage screens to separate fiber (cardboard, newspaper, and mixed paper), plastic, metal and glass containers, and small contaminants. This is usually accomplished through the use of mechanical, optical or pneumatic screening equipment to separate materials into size classifications and/or light versus heavier materials. Fiber is usually hand sorted off elevated conveyor platforms into commodities and dropped into bunkers below. Containers are processed through ferrous magnets, eddy-current magnets, air screens and hand sorting. The small contaminant stream (dirt, rocks, broken glass and ceramics, bottle caps, etc.) may be further processed by optical/pneumatic
sorting. Sorted material is moved from bunkers and baled (fiber, plastic, metal) or loaded directly into roll-off trucks (glass). The remaining material is shipped to a local landfill or another appropriate waste processing/conversion facility. The typical purpose of this type of MWPF is to remove recyclable material from MSW prior to landfilling or for pre-processing prior to an advanced conversion technology. Traditional MRFs typically recover about 10 to 25 percent of the recyclable waste stream while advanced MWPFs reportedly can achieve up to 50 percent recovery. There is a wide range of capacities operating throughout the world. The optimal capacity is between 200 tpd and 1,500 tpd using multiple sort lines and operating additional shifts. MWPFs can have a useful operating life of 20 to 30 years if proper maintenance is provided. Many MWPFs will be retrofitted throughout their life with new processing equipment as it wears out or as new technologies become available.

Pros: MWPFs and MRFs are fully developed and used through the United States and the world to process MSW (either mixed or commingled) to recover recyclable and reusable materials. This technology has the ability to process a wide range of MSW materials and yield potentially high recyclable recovery rates. It is well-proven technology, and various mechanical, pneumatic and optical processes are updated continually. This technology is being used more and more as a pre-processing step in preparing feedstock for thermal, biological and chemical processes. A local benefit is the creation of construction jobs over the one to two-year construction period and approximately 20 to 60 permanent jobs, depending on the size and complexity of the facility.

Cons: The economics are dependent largely on fluctuations in the commodity markets and local waste stream and an end use for the produced waste stream must be established; otherwise 60-80 percent of the incoming MSW will still ultimately end up being sent to a landfill. Environmental impacts must be mitigated such as noise, dust and odor. In addition, some of the commodities recovered from a MWPF can be contaminated with MSW to varying degrees depending on the processes in use.

Cost – LOW. In 2011, the county of Kauai, HI received a report that estimated a capital cost for a MWRF to be $25,000 to $30,000 per ton of daily design capacity; operation and maintenance costs were estimated at $30 to $35 per ton processed.

4.5.2 Autoclave/Steam Classification

Autoclaving is classified as a mechanical process that uses heat and pressure in a mechanical rotating cylinder to separate the cellulosic material from other portions of the municipal solid waste stream. The basic autoclave technology has been in use for sterilization of biomedical wastes and equipment and other related applications for many years.

Like anaerobic digestion, autoclaving addresses only a portion of the waste stream, namely the cellulose-fiber-containing portion, which is usually 40 to 60 percent of the total MSW input stream. However, this technology can accept mixed MSW which contains a large organic fraction (just not inert materials from a C&D mix) to be used as a front-end to many of the other emerging technologies such as hydrolysis for production of a fuel product, gasification or pyrolysis for energy generation, anaerobic digestion for energy and compost production, or for fiber recovery for the pulp/paper industry. A trommel screen is usually utilized after autoclaving to separate out the various mixes of fibrous organic materials produced from autoclaving and other materials (i.e., fine organics stream, bulky organics
stream, and overs, such as inorganic materials, and recyclables such as glass, metals and plastics).

Autoclaves are large rotating vessels that have steam injected and kept at a certain temperature and pressure over a 2 to 4-hour period to convert the MSW. Autoclaves are currently operating in batch mode accepting from approximately 1 to 25 tons per batch (2-3 hour). Figure 4.7 shows a small autoclave unit (~1 ton per batch) used by the Salinas Valley Solid Waste Authority for testing at their Crazy Horse Landfill in Salinas, California.

The autoclave process has the potential for a 40 to 60 percent reduction in waste volume with the cellulose recovery having the potential to be used as feedstock for:

- Paper production;
- Ethanol production feedstock;
- Compost feedstock; or
- Digester feedstock for methane production.

**Pros:** Benefits include the diversion of materials from landfills and the production of a valuable cellulose product. A local benefit is the creation of construction jobs over the construction period and a certain amount of permanent jobs over the life of the project.

**Cons:** The environmental risks of autoclaving are not known and this technology could be used primarily as a front-end system to prepare materials for other processes such as fiber recovery and thermal technologies. There are no large-scale commercial autoclave facilities operating in North America that use a purely mixed MSW stream as a feedstock. All of the demonstration projects were completed on a fairly small scale (less than 300 tpd) on different feedstocks besides MSW. No known commercial operation exists at this time in the United States or elsewhere for processing MSW. Water use and wastewater generation is also not known.

![Figure 4.7 Example of Autoclave](Source: HDR photo of Autoclave Unit, Salinas, California)
Cost – LOW. A 2006 DEFRA study in the United Kingdom indicated a 320 tpd facility would have a capital cost of approximately £15 Million ($23M) and an operation and maintenance cost of £25-45/ton ($38-$70/ton). However, the autoclave may only be the pre-processing method prior to another conversion technology.

4.5.3 Refuse Derived Fuel Production

An RDF processing system prepares MSW by using separation, shredding, screening, air classifying and other equipment to produce a fuel product for either on-site thermal processing, off site thermal processing, or use in another conversion technology that requires a prepared feedstock. The goal of this technology is to derive a more homogeneous fuel product that can be used in specified thermal equipment. The fuel goes by various names but generally is categorized as RDF.

Facilities can range in size from several hundred tons per day to more than 3,000 tons per day. Pre-processing via an MWPF is typically built into an RDF facility to remove metals and other undesirables and prepare the remaining materials for the conversion technology. An RDF facility strives to develop a consistently-sized fuel with a relatively constant heating value for thermal technologies. These facilities can employ multiple shredding stages, large trommel screens or other types of screens for sizing, several stages of magnets, and possibly air separation and eddy current magnets. The product will typically have a nominal particle size of three to four inches (although the sizing of final product RDF can be controlled for a specific technology), have the grit and metals largely removed, and be ready to market.

Some RDF facilities can be classified as a shred and burn style, which shred the material and magnetically remove ferrous metals without removing fines. Fines usually consist of material two inches in diameter or smaller that include organic material such as paper, dirt and food particles as well as inorganics such as glass, plastics and metals. Some RDF facilities have converted to shred and burn throughblanking the small holes in trommels. The purpose of this is to reduce the overall amount of residue (fines) that is landfilled.

There are several examples of RDF plants in the United States that use varying degrees of preprocessing. RDF front-end processing can create challenges for the facility. Explosions can occur in the shredders, thus requiring, at a minimum, the primary shredders to be placed in explosion-resistant bunkers. MSW is very abrasive, which causes wear and tear on all components. All systems are subject to high maintenance costs and require extensive repairs and frequent cleaning to keep the facility online. Normally, processing occurs on one or two shifts with a shift reserved each day for cleaning and maintenance. Therefore, processing systems need to be sized larger than the associated thermal equipment, and storage capacity must be provided both for incoming waste and for RDF to keep the facility running smoothly. With proper maintenance, RDF facilities can have a useful operating life of 20 to 30 years. Many RDF facilities are retrofitted throughout their life with new processing equipment as applicable.

When the thermal facility is not co-located with the RDF processing facility, communications and arrangements need to be established and maintained between the two facilities and on-site storage of RDF is important for both facilities.

Figure 4.8 shows an example of stockpiled RDF at a facility in Rennerod, Germany.
RDF technology is a proven technology used at a number of plants in the United States, Europe and Asia. There are also a number of commercial-ready technologies that convert the waste stream into a stabilized RDF pellet that can be fired in an existing coal-boiler or cement kiln. Some RDF plants within the United States include facilities at Ames, IA; Southeastern Public Service Authority, VA; French Island, WI; Mid-Connecticut; Honolulu, HI; and West Palm Beach, FL.

![Example of stockpiled RDF](source: HDR photo of Rennerod, Germany Facility)

**Pros:** The RDF technology is a proven technology. Benefits include the preparation of the MSW into a feedstock that is acceptable by other processes allowing them to be more effective and efficient. The process removes recyclables and reusable materials from the waste stream for beneficial use. A local benefit is the creation of construction jobs over the one to two-year construction period and approximately 10 to 100 permanent jobs, depending on the size and complexity of the project.

**Cons:** A drawback is that RDF facilities have some air emissions directly from the processing (dust) as well as from the combustion of the RDF (this is discussed in the thermal technologies section). Fugitive particulates from the process must be controlled. In addition, other environmental impacts must be mitigated such as noise and odor. Costs for this type of facility vary greatly based on the amount of revenues garnered from sale of the RDF product (if sold) instead of used internally. An economic drawback of RDF (if pelletized) is that it produces a solid fuel similar to coal; production of this type of RDF product presumes a local market for a coal-substitute to be economically viable.

**Cost – MEDIUM.** In 2006, the estimated capital cost for the 1,000 tpd Rock-Tenn Biomass RDF Facility in St. Paul, MN was $140,900,000; estimated annual operation and maintenance costs was about $14,000,000/year. Recently, WastAway claimed that they can build a 200 tpd RDF facility that produces a pellet that has a BTU content of 8,000 to 9,000 BTU/pound for about $22,000,000.
4.6 Summary

Due to the County’s many years of operational experience with its existing comprehensive solid waste processing and disposal facilities, HDR believes that only a few of the many potential technology options described will be a good fit or be applicable to the County. Some factors to consider:

- Is it considered proven technology, i.e.:
  - currently in use
  - having an operating record of at least three years, and
  - where the daily quantity of MSW processed is equal to or greater than the County’s projected solid waste flow;
- The extent to which the technology is capable of processing a feedstock similar to County’s waste stream characteristics;
- The optimal throughput capacity;
- The landfill diversion rate and amount of process residuals;
- Will the technology require additional pre-processing prior to use as a feedstock;
- The potential type of products produced by the technology which can be sold in the commodities market;
- The approximate range of useful operating life;
- Typical or commonly-cited environmental benefits and drawbacks of the technology; and
- The potential for local economic benefit (e.g., job creation, correlation to other industrial uses/synergy).

HDR’s findings from previous review and evaluation of alternative technologies indicate that some technologies appear to be less attractive than others, mostly due to the level of commercial development with respect to being capable of processing MSW as the feedstock, of the type and quantity generated by Pinellas County. The technologies which are the least developed and therefore not recommended for further consideration include:

- Pyrolysis
- PAG
- Hydrolysis
- Catalytic and thermal depolymerization
- Autoclaving.

Table 4.1 provides a summary of key metrics regarding remaining possible technology options.
<table>
<thead>
<tr>
<th>Proven Technology?</th>
<th>Capable of processing County MSW</th>
<th>Throughput potential and residue</th>
<th>Pre-processing</th>
<th>Commodity markets</th>
<th>Useful operating life</th>
<th>Environmental benefits or drawbacks</th>
<th>Local Economic Benefit</th>
<th>Potential for Pinellas</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thermal – Direct Combustion</td>
<td>Yes</td>
<td>Yes</td>
<td>3,000 to 4,000 tpd</td>
<td>90% airspace reduction</td>
<td>Waste screening but minimal</td>
<td>Ash reuse developing, metal recovery and electrical generation</td>
<td>20-30 years or longer with upkeep and retrofits</td>
<td>Offset landfill gas, requires large water intake, high capital cost</td>
</tr>
<tr>
<td>Thermal - Gasification</td>
<td>Yes</td>
<td>Yes, with processing and screening</td>
<td>Low, 300 tpd</td>
<td>90% airspace reduction</td>
<td>Shredding and screening required, often select waste streams</td>
<td>Liquid fuel potential, reuse of slag unknown</td>
<td>No long term data to support</td>
<td>Slag does not leach, syngas for energy, high capital and operating cost</td>
</tr>
<tr>
<td>Biological – Aerobic Composting</td>
<td>Yes</td>
<td>Organic fraction only</td>
<td>Low, 500 tpd</td>
<td>50% reduction but material is marketable</td>
<td>Shredding, screening, contaminant removal</td>
<td>End product is marketable as soil amendment</td>
<td>Minimal structural components, long term operations</td>
<td>Offset LF disposal, positive soil amendment, can create odors, moderate capital costs</td>
</tr>
<tr>
<td>Biological – Anaerobic Digestion</td>
<td>Yes</td>
<td>Organic fraction only</td>
<td>Low, 50 tpd</td>
<td>Material reduction, end products can be marketed</td>
<td>Shredding, slurries and contaminant removal</td>
<td>Biogas for energy production, digestate can be further processed into compost</td>
<td>20 year with upkeep and retrofits</td>
<td>Offset LF disposal, energy and compost markets, moderate capital and operating costs</td>
</tr>
<tr>
<td>Proven Technology?</td>
<td>Capable of processing County MSW</td>
<td>Throughput</td>
<td>Diversion potential and residue</td>
<td>Pre-processing</td>
<td>Commodity markets</td>
<td>Useful operating life</td>
<td>Environmental benefits or drawbacks</td>
<td>Local Economic Benefit Potential for Pinellas</td>
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<tr>
<td>Biological – Mechanical Biological Treatment (MBT)</td>
<td>Yes</td>
<td>Entire MSW stream</td>
<td>Low, 100 tpd</td>
<td>50% reduction, residue must be landfilled or processed for disposal</td>
<td>Shredding, screening</td>
<td>Energy and heat generation</td>
<td>20 year with upkeep and retrofits</td>
<td>Partial landfill diversion, energy and heat markets, high residual, moderate capital and high operating costs</td>
</tr>
<tr>
<td>Chemical – Waste to Fuel</td>
<td>Yes, primarily woody waste</td>
<td>Can process MSW but limited history</td>
<td>Low 300 tpd</td>
<td>High, similar to gasification</td>
<td>Shredding, screening</td>
<td>Syngas production to liquid fuels for market</td>
<td>Unknown</td>
<td>High diversion but limited to woody wastes, high capital and operating costs</td>
</tr>
<tr>
<td>Mechanical – Mixed Waste Processing Facility</td>
<td>Yes</td>
<td>Entire MSW stream or recyclables streams</td>
<td>Up to 1,500 tpd</td>
<td>Low 50% recovery rate, residue must be processed or disposed</td>
<td>Waste screening</td>
<td>Recyclables for commodity markets</td>
<td>20-30 yrs</td>
<td>Moderate diversion, large recyclables capture, low capital cost but economics rely on commodity markets</td>
</tr>
<tr>
<td>Mechanical – Refuse Derived Fuel</td>
<td>Yes</td>
<td>Entire curbside MSW, no bulky materials</td>
<td>High, 3,000 tpd</td>
<td>Similar to thermal combustion</td>
<td>Shredding and screening</td>
<td>Recyclables and material is fuel for thermal combustion</td>
<td>20-30 yrs</td>
<td>Offset landfill disposal, residual may have emerging markets, some dust with preprocessing, moderate capital and operating costs</td>
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</tbody>
</table>
As noted in Table 4.1, some of the technologies considered have limitations with respect to the types of feedstock they can process. For example, biological technologies such as anaerobic digestion and composting can only affect the organic portion of the non-recyclable discards.

Any given new technology could take as few as three years to permit and construct or as many as 10 years depending on local political climate, environmental/regulatory permitting, acceptance by the public, and local opposition. All of the processes described herein have some residual product that will likely need to be landfilled. Whether this is ash from a WTE facility or spoils from a composting facility, some portion of the waste stream will need a final disposal site – typically a landfill. The County is in a very favorable situation given the remaining life of the Bridgeway Acres landfill.

5 References

FDEP Permit Number FL0040436, (2018). Minor Revision, South Cross Bayou AWRF, File No. FL0040436-024-DWF/MM.

FDEP Permit Number FLA128848, (2018). Permit Application by City of St. Petersburg. File No. FLA128848-021-DW1/NR.

FDEP Permit Number FL0021857, (2016). Permit Application by City of Clearwater Public Utilities Department. File Number: FL0021857-018-DW1P/NR

FDEP Permit Number FL0128937, (2018). Minor Revision, Clearwater Northeast WRF, File No. FL0128937-014-DW1P/NR, Revision No. FL0128937-015-DW1/MR.

FDEP Permit Number FLA128830, (2017). Permit Application by City of St. Petersburg. File No. FLA128830-018-DW1P.


