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Abstract
This paper focuses on significant changes in the overall economics of waste-to-energy (WTE) during the last 30 years. The WTE industry in this country has seen several different business cycles occur since 1975, as different market drivers have caused the industry to rise and fall. This paper compares: (1) those economic factors that were in play in 1975, when the first WTE facility in the United States was built, and the industry was in its infancy; (2) the factors at play when the WTE industry was at its height in 1990; and (3) some of the factors that caused the industry's steep downward trend since 1994, when the last greenfield WTE facility in the United States was built. The paper will identify changes that have occurred with regard to the pricing of electricity and the ability of public sectors to charge non-market-based tipping fees. The paper discusses the drivers of 2006 and focuses on completed economic factors to be considered when comparing WTE with other waste disposal means. The paper discusses the drivers of 2006 and whether the industry is finally poised to begin an upward turn in the cycle. The paper focuses on the impact of the cost of diesel fuel oil on the overall economics of long-haul transfer, and how that is likely to impact the future development of WTE facilities. The paper also presents a case study of a recent analysis that was undertaken for two counties that were evaluating the financial viability of WTE as compared to other disposal options.

Introduction
The WTE industry in the United States has seen several different business cycles during the last 30 years as different market drivers have caused the industry to rise and fall. This paper compares those economic factors that were in play at the outset of the industry in 1975, how those factors had changed at the height of the industry in 1990, and what economic factors are currently impacting the market. The paper presents recent planning cost estimates on alternative methods of disposing of solid waste and raises the question as to whether current economic factors have changed enough to cause the WTE industry to start a new, although significantly less aggressive, upward cycle once again.

A Brief History – 1975 to 1990
The author has been involved in the preparation of independent engineer’s reports used in the financing of WTE facilities since 1974, and has observed several different cycles in the WTE industry during the last 30 plus years. When the 1,500 tons-per-day (TPD) facility in Saugus, Massachusetts was financed in 1975, it was necessary to explain the basic concept of a WTE facility to prospective bond purchasers who were skeptical of its economic viability for a number of reasons:

1. Most municipalities still had a hole in the ground where they were dumping their solid waste. Why would a municipality pay as much as $20 to $25 per ton to dispose of it elsewhere?
2. The technology had not been commercially demonstrated in the United States. Why would a municipality sign a 20-year contract to deliver waste to a facility that might or might not work?

3. The electric utility industry was constructing large nuclear power plants, as well as constructing dams to generate hydroelectricity. With plentiful, relatively inexpensive power, why would a private electric utility sign a 20-year power purchase agreement with a WTE facility? This was particularly true for electric utilities that, in 1975, enjoyed complete monopolies in their service areas and were more concerned with their allowed rate of return on rate base than being competitively priced in the market place.

The WTE industry as a whole faced some significant obstacles in the early 1970s at the beginning of the business cycle.

In the 15 years that followed financing of the Saugus Facility in 1975, questions regarding the technical viability of the technology were eventually answered, although not without some serious bumps in the road (think of the first WTE facilities that were constructed in Bridgeport, Connecticut and Baltimore, Maryland). However, two of the biggest boosts the industry received came from the federal government during the 1970s. The passage of the Resource Conservation and Recovery Act (RCRA) provided legislation which required that environmentally improved methods of waste disposal be developed by communities. It would no longer be acceptable to simply throw solid waste into an un-lined hole in the ground. The cost of solid waste disposal immediately increased, with RCRA’s passage and eventual implementation.

The second piece of federal legislation which benefitted the solid waste industry was the Public Utilities Regulatory Policy Act (PURPA). This legislation required that privately owned utilities purchase electric energy from facilities that utilized alternative sources of fuel, including municipal solid waste. The legislation further required that the price the utilities pay for such power be set at the utility’s avoided energy cost, which normally represented that utility’s most expensive, least efficient, least frequently dispatched means of generation. As a result of PURPA, owners/operators of WTE facilities found themselves able to negotiate long-term power purchase agreements that included provisions for making energy payments that were often significantly above the market rates. The value of the by-product being produced by WTE facilities, electricity, went up significantly and, when combined with the increased cost of alternative methods of solid waste disposal and the lack of available land in certain densely populated areas, provided the necessary impetus for the upward trend in the development of WTE facilities in the late 1970s and early 1980s.

The solid waste industry remained in this upward cycle for most of the 1980s, as many communities, particularly along the East Coast of the United States, looked to WTE facilities as one of the primary means of solid waste disposal. A significant percentage of the solid waste generated in Long Island, New York; Massachusetts, Connecticut; eastern Pennsylvania, Maryland, and Florida was being combusted in WTE facilities by 1990. The success that was experienced in the 1980s was further enhanced by the concept of “legal flow control.” This referred to the legal right of public sector entities to direct where solid waste that was generated within that community’s geographic boundaries would be disposed. Two of the principal concepts behind legal flow control were: (1) it was necessary for the health and safety of the community to assure that solid waste was properly disposed; and (2) long-term financing could be obtained only if bond investors could be assured that a contractually secured source of solid waste was available to a WTE facility – both as a fuel and as a source of tipping fee revenues.

Legal flow control was also critical to communities, counties and solid waste authorities, because they were not competing on
a level playing field with the owners of private waste disposal facilities. In addition to paying for the cost of solid waste disposal, many public sector solid waste entities were also required to pay for: recycling, the disposal of household hazardous waste, public information programs and other programs that were not financially self-supporting. The tipping fee that was required to be charged by a public entity to pay for the entire solid waste management program was usually higher than the tipping fee a private sector operator could charge for just the disposal of solid waste at a landfill. Legal flow control provided the means by which public sector solid waste entities could charge an above-market tipping fee and still expect solid waste to be delivered to their system.

The upward cycle of the WTE industry continued into the late 1980s as the main drivers in the industry during the 15 years from 1975 to 1990 were: (1) the closure of many publicly owned dumps and landfills; (2) the availability of above-market energy prices; and (3) the presence of legal flow control.

The market during the 1980s was also characterized by a number of large companies that were competing for a share of the WTE market place. Among the companies that were developing, or attempting to develop projects, were the following: Wheelabrator, General Electric, Westinghouse, Ogden Martin, Katy-Seghers, Consumat, Enercon, Montenay, Dravo, Foster Wheeler, American Ref-Fuel and Raytheon. There were a number of serious players in fierce competition with one another.

**Changing Market Drivers**

By 1990, the market for the WTE industry had started to change. The country experienced a recession in 1988 which had an impact on the general economy. As businesses closed and jobs were lost, the amount of commercial solid waste being generated in many parts of the country decreased. The amount of solid waste requiring disposal was also impacted by the wide-spread implementation of effective recycling programs in many parts of the United States. A number of states formulated solid waste management plans which called for the recycling of anywhere from 25 to 50 percent of the waste stream. Many states reported that they were able to reach recycling levels that ranged from 30 to 35 percent of the waste stream. The combination of: (1) the reduction in the amount of waste being generated, and (2) the reduction in the amount of waste being disposed due to the success of recycling efforts, resulted in a number of WTE facilities being forced to significantly reduce spot market and short-term contractual tipping fees. This reduction was necessary in order to attract a sufficient supply of solid waste, not under long-term contract, to allow the facility to be operated at its maximum energy generation capacity. After 15 years of increasing success, the WTE industry was beginning to see the leveling off in the cycle.

The leveling off was accelerated by the permitting and construction of “mega” landfills located in Pennsylvania, Virginia, Ohio and central and western New York. Through economies of scale, privately owned landfills sized at 2,000 to 3,000 TPD were able to offer significantly lower tipping fees for the disposal of solid waste – provided the solid waste was free to travel to such landfills. The industry was further buffeted in the early 1990s by the fact that electric utilities were feeling less pressure to execute power purchase agreements that included above-market electric rates. In fact, during the 1990s a number of utilities began “buying down” power purchase agreements that included above-market prices.

By the early 1990s, marketplace drivers had changed as follows: (1) the introduction of large, privately owned landfills served as a source of potential competition at significantly lower tipping fee; (2) there was a reduced quantity of waste requiring disposal; and (3) there was a reduction in the willingness of electric utilities to execute power purchase agreements with above-market prices. The cycle was leveling off in 1990, but would plunge precipitously in 1994.
Loss of Flow Control

Those individuals who have worked in the WTE industry in the United States since its inception in the 1970s have different views on why the industry moved into such a pronounced downward cycle in 1994 and stayed there. Arguments can be, and have been, made regarding any and all of the following:

1. Decreased waste quantities
2. Advent of effective recycling programs
3. Environmental concerns with air emissions and the generation of residue ash
4. Reduced energy prices
5. Development of mega landfills.

All of these were contributing factors. However, it is the author’s belief that the single largest reason for the downturn of the WTE industry as we knew it in 1990 was the U.S. Supreme Court’s Carbone decision in 1994, which largely, but not completely, eliminated the ability of public entities to legally direct where solid waste should be disposed. The inability of the public sector to continue to control the waste stream meant that communities could no longer contractually guarantee to deliver all of the solid waste generated within that community’s geographic boundary.

The inability of a public entity to be able to guarantee the delivery of a waste stream meant that there was a risk of a shortfall in waste deliveries if an alternative disposal offered private haulers a lower cost disposal option. The potential loss of solid waste could mean a risk that there would be a reduction in tipping fee revenues and electricity generation revenues. Prospective bond purchasers hate risk when they consider purchasing a revenue bond. Bondholders could no longer be guaranteed that solid waste would be delivered, so they were reluctant to purchase the revenue bonds which were being offered to finance WTE projects. Because WTE projects are capital-intensive and require hundreds of millions of dollars of investment, the inability to obtain financing seriously impaired the ability to develop WTE facilities after 1994. The loss of flow control in 1994 caused the WTE industry’s business cycle to drop dramatically. After the Carbone decision, the only “greenfield” WTE project that was financed in the United States was the November 1994 financing of the Robbins Facility, located in Cook County, Illinois. [Unfortunately for the bondholders of the Robbins Facility, in 1996 the State of Illinois rescinded the legislation requiring electric utilities to pay Qualified Solid Waste Energy Facilities a price for electricity which is equal to the average amount per megawatt hour paid by the local government owning or served by the WTE facility. The loss of that legislation reduced electricity revenues for the Robbins Facility by approximately 80 percent, resulting in the facility no longer being economically viable.]

The loss of flow control also meant that public sector entities had to charge a market-based tipping fee and it placed them in direct competition with the private operators of landfills. Many solid waste authorities confronted significant financial challenges after 1994, because they were required to pay for all the additional services in addition to disposal.

The Current Market

Between 1994 to 2006, no “greenfield” WTE facility has been developed in the United States. The conventional wisdom for the last ten years has been that the WTE industry was fated to follow the same cycle as the nuclear energy industry — a downward cycle, with no apparent chance to recover. Similar to nuclear power plants, there were few champions of WTE facilities in the general public due to the high capital and operating costs, concerns with air emissions, and less expensive alternative means of disposal. There were serious questions as to whether another new WTE facility would even be constructed in the United States. During the last ten years, there were no positive market drivers. Rather than driving anywhere, the WTE industry looked like an abandoned car that had run out of gas and been abandoned along the side of the highway.
However, during the last 12 - 18 months, there have been glimmers of a renewed interest – or perhaps curiosity – regarding WTE as a means of waste disposal, as evidenced by the following:

- Plant expansions are being considered in Honolulu, Hawaii; several counties in Florida; and two locations on Long Island, New York
- The City of New York is reportedly reconsidering whether WTE facilities should augment their marine terminal transfer stations
- The recently updated Solid Waste Management Plan for the State of Connecticut identifies a need for additional municipal solid waste disposal capacity in that State
- The islands of Maui and Hawaii are evaluating WTE as a disposal option
- Two counties in Maryland are considering WTE, among other alternatives, as part of their options for long-term solid waste disposal
- A retrofit/replacement of the WTE facility in Harrisburg, Pennsylvania is being considered.

**Comparative Disposal Options**

The author recently served as the project manager for an evaluation of solid waste disposal options available to two counties that have limited useful remaining lives at their county-owned landfills.

In undertaking the review of waste disposal options for the counties, R. W. Beck was charged with the following parameters:

1. The option had to extend, to the greatest degree possible, the useful operating lives of the two county-owned landfills.
2. Whatever technology was to be employed must have been previously demonstrated on a commercial basis. The counties were not interested in serving as the prototype for a new technology.
3. The option should provide a long-term solution (20 years or more) to the solid waste disposal problem.
4. The counties preferred public ownership of the facilities but wanted private development, construction and operation.
5. The option should be available for operation by 2012, when the existing long-haul disposal contracts are scheduled to terminate.

Working with staff from both counties, the following alternatives were identified for review and evaluation:

1. Continued landfilling at the county landfills.
2. Use of county-owned but privately operated transfer stations to transfer solid waste via trailer trucks for long-haul travel to landfills located outside the State.
3. The construction of a municipal solid waste composting facility that would compost all of the municipal solid waste generated in the counties, not just the organic stream.
4. The construction of a WTE facility sized to accept only the solid waste generated within that particular county.
5. The construction of a regional WTE facility sized to accept the solid waste generated within both of the counties.

In undertaking the analysis, we included consideration of the costs of the counties’ existing solid waste management systems, including recycling, transfer station, operations, landfill operating costs, additional landfill cell development costs, and out-of-county transportation and disposal.

In order to accommodate the differences in capital costs, operating expenses, and timing of expenditures associated with the different options, R. W. Beck calculated a net present value of the total cost of disposal over the 20-year study period based on an assumed discount rate.

All of the options were evaluated over a 20-year operating period from 2012 through 2031.
Estimates were developed for the following:

- Capital costs of:
  - Future landfill cells at the counties’ landfills
  - A municipal solid waste composting facility
  - WTE facilities sized at:
    - 600 TPD
    - 900 TPD
    - 1,500 TPD
- Operating expenses of:
  - Landfill cells owned by the counties
  - Long-haul transfer, transportation and disposal
  - Municipal solid waste composting facilities
  - Unit operating costs ($/ton of waste) of WTE facilities sized at:
    - 600 TPD
    - 900 TPD
    - 1,500 TPD
- Long-range projections of the price of energy sold into the local power grid
- Estimates of Renewable Energy Credits payments
- The potential value of compost product produced from municipal solid waste.

All options were assumed to involve: level debt service payments; public ownership and the issuance of tax-exempt bonds. To the greatest extent possible, planning assumptions were held constant for the various options.

The results of the analysis for County A are summarized in Table 1, below.

<table>
<thead>
<tr>
<th>Table 1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Summary of Estimated Cost of Solid Waste Management – County A</td>
</tr>
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</table>

<table>
<thead>
<tr>
<th>Option</th>
<th>Nominal Cost</th>
<th>Net Present Value</th>
<th>Nominal Cost $/Ton</th>
<th>Net Present Value - $/Ton</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. County Landfill</td>
<td>$407</td>
<td>$221</td>
<td>$50</td>
<td>$27</td>
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<tr>
<td>2. Regional 1,500 TPD WTE Facility (1)</td>
<td>492</td>
<td>270</td>
<td>61</td>
<td>33</td>
</tr>
<tr>
<td>3. Long Haul – With Inflation</td>
<td>542</td>
<td>287</td>
<td>67</td>
<td>36</td>
</tr>
<tr>
<td>4. Compost Facility – Landfill Residue</td>
<td>550</td>
<td>298</td>
<td>68</td>
<td>37</td>
</tr>
<tr>
<td>5. Compost Facility – Long Haul Residue</td>
<td>599</td>
<td>320</td>
<td>74</td>
<td>40</td>
</tr>
<tr>
<td>6. Compost Facility – No Market – Landfill</td>
<td>602</td>
<td>322</td>
<td>74</td>
<td>40</td>
</tr>
<tr>
<td>7. 600 TPD WTE Facility</td>
<td>645</td>
<td>343</td>
<td>80</td>
<td>42</td>
</tr>
<tr>
<td>8. Compost Facility – No Market – Long Haul</td>
<td>651</td>
<td>344</td>
<td>81</td>
<td>43</td>
</tr>
<tr>
<td>9. Long Haul – Increased Transportation</td>
<td>746</td>
<td>370</td>
<td>92</td>
<td>46</td>
</tr>
</tbody>
</table>

(1) NOTE: Costs represent County A’s 40 percent ownership interest in a 1,500 TPD Facility.

The information in Table 1 indicates that the lowest disposal cost option for County A would involve a continuation of landfilling at the county-owned landfill. This result is not
surprising, because this option involves the lowest transportation cost, lowest level of capital expenditure and lowest level of operating expenses. However, this was not an option that County A wanted to pursue for a variety of reasons, including land use issues, the difficulty in siting a new landfill, the problems associated with finding a 300- to 400-acre parcel of land and the strong desire to preserve air space at the existing landfill. Therefore, for non-economic reasons, County A did not consider continued landfilling as a viable option.

The next lowest-cost option which met the county's other criteria was the construction of a regional 1,500 TPD WTE facility. For County A, the regional approach is financially viable because of the economies of scale associated with a 1,500 TPD facility. It is worth noting that the smaller 600 TPD WTE facility ranked seventh on the list because of the higher unit-per-ton capital costs and operating and maintenance expenses.

The long-haul transfer option was the third least expensive option IF one assumes that the cost of long haul increases each year during the study period at the assumed annual rate of inflation of 2.4 percent. However, the numbers change significantly if one assumes that the cost of long-haul transportation increases at twice the rate of inflation due to continued increases in the cost of diesel fuel and the need to utilize increasingly more distant landfills as closer landfills are filled to capacity during the study period. While the actual cost of long haul may not increase at twice the rate of inflation over a 20-year period, the analysis does demonstrate the sensitivity to increases in both the cost of diesel fuel and the longer distance to be traveled to access more remote landfills.

The four municipal solid waste compost options had the following variations:

(a) Landfill Residue – assumes all residue remaining after the composting of municipal solid waste is disposed in the county landfill. Also assumes the county is able to give the final compost material away at no cost to the county.

(b) Landfill – Long-Haul Residue – assumes all residue remaining after the composting of municipal solid waste is long-haul transferred for disposal out of state. Assumes the county is able to give the final compost material away at no cost to the county.

(c) No Market – Landfill Residue – assumes all residue from the composting of solid waste is disposed in the county landfill. Assumes the county must pay to transport the final compost product to a site located outside the county.

(d) No Market – Long-Haul Residue – assumes all residue from the composting of solid waste is long-haul transferred for disposal out of state. Assumes the county must pay to transport the final compost product to a site located outside the county.

It is important to note that the financial analysis of the municipal solid waste composting options were heavily influenced by the marketing of the final compost product and whether markets could be developed for the quantity of compost that would be generated. Because the counties were seeking a solid waste disposal option that would be capable of processing all the municipal solid waste, the composting option was based on the assumption that the composting facility would process all municipal solid waste, not just the organic stream. Previous experience indicates that the final compost product produced from municipal solid waste can have a significant amount of inorganic material that does not compost and impacts the value of the final product. For that reason, in two of the compost scenarios, we assumed that the compost could be given away at no charge. In two additional scenarios, we assumed the compost would have no value and the county would have to pay the cost to transport the material to some out-of-county location. A second concern was with the sheer quantity of compost product being produced and the ability to find a credit-worthy entity that could utilize between 500 and 1,200 TPD of final compost product that was produced from municipal solid waste.
We prepared somewhat similar comparative cost analyses for County B. The results for County B are set forth in Table 2, below.

### Summary of Estimated Cost of Solid Waste Management – County B

<table>
<thead>
<tr>
<th>Option</th>
<th>Nominal Cost</th>
<th>Net Present Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Regional 1,500 TPD WTE Facility (1)</td>
<td>$ 960</td>
<td>$506</td>
</tr>
<tr>
<td>Long Haul - Inflation</td>
<td>1,003</td>
<td>520</td>
</tr>
<tr>
<td>Compost Facility – Landfill Residue</td>
<td>1,065</td>
<td>556</td>
</tr>
<tr>
<td>Compost Facility – Long Haul Residue</td>
<td>1,126</td>
<td>581</td>
</tr>
<tr>
<td>900 TPD WTE Facility</td>
<td>1,146</td>
<td>596</td>
</tr>
<tr>
<td>Long Haul – Increased Transportation Costs</td>
<td>1,269</td>
<td>628</td>
</tr>
</tbody>
</table>

(1) - Represents County B's share of the cost of 60 percent of a 1,500 TPD Facility

The results for County B are relatively similar to those for County A, with the regional 1,500 TPD WTE facility representing the lowest cost option, followed by the long-haul transfer option if the transportation cost increases at inflation. Long haul is calculated to be the most expensive option if transportation costs increase at twice the rate of inflation.

**The New Drivers**

In preparing the analyses which were undertaken in 2005 and are discussed above, certain significant changes were made to planning assumptions that would have been used in 1980 or 1990 as they relate to estimating the cost of waste disposal at a WTE facility.

The factors which, in 2006, drive the comparative analyses of the cost of disposal via WTE compared with other options are as follows:

1. Revenues from the sale of electricity generated by WTE facilities will no longer be based on above-market prices. However, as the price of fossil fuels continues to rise, the value of the electricity from WTE facilities is increasing as well.

2. Significant savings can be achieved through the economies of scale associated with larger facilities, as is evident when considering the capital and operation costs of 600, 900 and 1,500 TPD facilities. This means that efforts should be made to regionalize WTE facilities and develop as large a project as possible.

3. The long-haul transfer option is significantly impacted by the cost of transportation of solid waste, particularly via transfer trailer. The increasing cost of diesel fuel oil, coupled with longer driving distances, have the potential to have a significant impact on this alternative means of waste disposal.

4. To the extent that new landfills are located in more distant locations from solid waste centroids, the relative cost of long-haul transfer is likely to increase.

5. Facilities which compost the entire municipal solid waste, rather than just the organics stream, will continue to face challenges related to the quality of the final product, markets for the final product and the demonstrated capability of the technology.
6. Innovative solid waste processing technologies continue to be developed, including: (a) waste-to-ethanol; (b) waste gasification that converts solid waste to a fuel gas with the use of some oxygen; (c) the conversion of plastics to oil; (d) pyrolysis systems that convert solid waste to a fuel gas in the absence of oxygen; (e) plasma systems that use plasma torches to provide the energy to convert solid waste to a fuel gas; and (f) the chemical and biological conversion of the cellulose fraction of municipal solid waste stream to ethanol. While test reports look interesting, most of the technologies have operated only on a pilot scale or represented an adaptation of technologies with experience on a uniform biomass feedstock such as wood or rice hulls. Questions remain regarding the ability of these technologies to take unprocessed municipal solid waste and produce power as the end product. Furthermore, issues regarding scale-up have yet to be addressed.

7. Earlier questions regarding the technical viability of mass-burn and RDF WTE facilities have been answered – they can be made to work as intended.

8. Earlier questions regarding environmental emissions from WTE facilities have been answered – they can be operated within permit requirements.

9. The number of major players currently in the marketplace has been reduced to just three.

10. Prospective bond purchasers will continue to have concerns with waste supply issues, absent the currently unanticipated return of legal flow control. This means that the owners of WTE facilities will have to charge a market-based tipping fee and that the economic viability of WTE facilities will be determined to a significant degree by the physical location of a proposed facility, and the proximity of that location to privately owned/operated landfills. The economic “break-even” distance to such landfills is likely to decrease as the price of diesel oil increases.

Summary

The WTE industry in the United States has experienced clear and distinct cycles during the last 30 years as it has responded to different marketplace drivers. The industry began at a low point in 1974 when solid waste was simply thrown into a hole in the ground and energy was just starting its upward climb in cost. By the late 1980s, the industry reached its zenith through a combination of above-market power prices, government regulation and legislation dealing with the disposal of solid waste, and the existence of legal flow control. Triggered by the Carbone decision in 1994, the industry went into an extended period of decline and has remained at its nadir for approximately 10 years.

Are we finally witnessing the beginning of another upward shift in the cycle? It is still too soon to tell and, barring some currently unforeseen event, it is unlikely that this industry will again approach the levels of the late 1980s. Nevertheless, several factors in the marketplace are aligning themselves in such a manner that WTE may again be a viable option for some communities that face land use issues and are not located in proximity to privately owned landfills. Continued increases in the value of electricity and the cost of diesel oil all work in favor of WTE facilities. Furthermore, the desire of communities to contract for a proven and commercially demonstrated technology and produce a marketable product, makes WTE one of the few currently viable alternatives to landfilling.