

Solid Waste Landfills The Road to Green Energy

Introduction

Disposal of solid waste, liquid waste and the ultimate in waste management – burial of the deceased, has been a societal problem since early man first dropped his knuckles while moving upright on two legs. Man learned to separate disposal from community living very early, but it was millennia before the impact of waste disposal on diseases and its transmission became common knowledge. While there was some suspicion of a relationship, it was not until the development of the microscope in the 17th century that the first cause/effect relationships were observed. Scientific progress was slow, and it required another 200 years, until in the middle of the 19th century, an action as simple as removal of the handle from a shallow and contaminated well on Broad Street in London effectively reducing the spread of cholera, dysentery and other water-borne diseases.

It was clear that the relationship between water-borne contamination and disease transmission was established, but not so clear was any relationship with solid waste disposal. Throughout the second half of the 19th century and the first half of the 20th century, public health emphasis was on water-borne mitigation of disease. Solid waste was considered more of a nuisance problem, but the combined impact of liquid and solid waste was impetuous for the passage of the 1899 Rivers and Harbors Act. After 1900 the rate of change for disposal of solid waste accelerated and Table No. 1 is a summary of the pertinent laws and regulations promulgated by the Federal Government or the Commonwealth of Pennsylvania. Regulatory involvement in other states followed a similar calendar, and Table No. 1 will be used as the basis to discuss their “Road to Green Energy”.

Table No. 1 – Milestones in Solid Waste Regulations

Year	Regulation
1899	River and Harbor Act
1963	Clean Air Act
1965	Solid Waste Disposal Act
1968	State of PA Act 241
1969	National Environmental Policy Act
1970	Resource Recovery Act
1970	Occupational Safety and Health Act

1972	Clean Water Act
1976	Resource Conservation and Recovery Act
1978	Public Utility Regulatory Act
1980	Comprehensive Environmental Response, Compensation and Liability Act
1980	State of PA Act 97
1987	State of PA Act 101
1995	Section 29 Tax Credits
2002	State of PA Act 90

What Energy?

In the 18th and 19th century it was known that anaerobic digestion of waste, both human and animal, would produce off gas that could be used as fuel. Methane digesters were widely used on farms for lighting and as fuel for pumps and other equipment before the massive push for rural electrification in 1932. When electricity became available, use of methane fuel ceased to play a significant role. Prior to World War II solid waste disposal was a mixture of three methods: Incineration in the larger metropolitan areas or ocean dumping for those near the coast. Open burning dumps, many in swamps and wetlands Industrial on-site burning or burial. Few restrictions existed for solid waste disposal, except for control of nuisances, until the second half of the 20th century. The concept of solid waste disposal in a sanitary landfill, i.e. no burning and the need to cover waste to control fires, flies and other vectors only evolved about 1950, although the concept was known for decades prior to that time. The amount of gas generated by a landfill was not known to be a problem because both open burning and absence of cover allowed gas to escape to the atmosphere and burning the reduced quantity of waste suitable for methane generation. After the number of operating sanitary landfills increased so significant numbers after 1960, gas generation was identified as a major factor in the design and operation of safe landfills.

1899 Rivers and Harbors Act

The 1899 Rivers and Harbors Act was passed to specifically address the problem of jetsam and flotsam in the waters that were used for transportation and shipping. Without reasonably available solid waste disposal, removal of accumulated trash and street waste (think horses) was simply washed into nearby rivers and bays. At many locations this waste also included domestic sewage or at best wastes that received primary treatment only. One must remember that this was still more than a quarter century before Streeter and Phelps postulated their seminal equation that linked the

quality of water with waste loading. As with most early laws in addition to floating waste, odor was the principal nuisance over which control was sought.

An interesting result of the Act was the requirement for harbor and port operators to site disposal landfills for items removed from the water. Many of these landfills ultimately served both for disposal of waste removed from the water as well as for the waste generated from the surrounding city or municipality. Marsh land and flood plains in proximity to the water front were widely used for waste disposal. Most of these landfills were open dumps and no effort was made to cover or control public health nuisances. As result no gas was generated nor any energy recovered from the open burning of waste deposited for disposal.

1900 to 1960

For the next sixty years numerous environmental regulations were passed to control smoke (air pollution) and both industrial and domestic wastewater. In Pennsylvania water and waste water acts were passed in 1907, 1912, 1937, 1945, but none of these had any significant impact on solid waste disposal. The first act that related directly to solid waste in streams was passed in 1955, and it related to coal fines discharged into the waters of the Commonwealth. Sedimentation dams and dredge spoil fills were common, but these were designated monofills and joint disposal with household and commercial waste was not practiced as was the case with 1899 Rivers and Harbors Act.

Clean Air Act of 1963

With the passage of this Act, the first regulations passed by the Federal government were implemented. This legislation was without real direction, so that local and state governments passed their own implementing legislation. Strong regulations were passed in California as well as in major U.S. cities including Philadelphia, New York St. Louis plus almost every major California city. Stunned by the quick and comprehensive local government response, the U.S. passed a much stronger and comprehensive Law in 1970. This Act was reauthorized in 1977 and 1990 and the most significant result of this law was the development of the New Source Performance Standards (NSPS) for specific industries. Subsequently standards were adopted for Waste-to-Energy plants as well as gas emissions from landfills. These regulations are known as the MACT or Maximum Achievable Control Technology. These MACT regulations have imposed significant influence on how solid waste is managed, and more importantly upon the cost for treatment and disposal.

MACT regulations for sanitary landfills require a landfill to control the emissions of all gases, dominantly methane and carbon dioxide, when the weight of emission exceeds 1000 metric tonnes. A collection system is required to channel all gas into a system for treatment or use of the gas in a manner that facilitates energy recovery. Simple

disposal, i.e. thermal destruction in a flare requires a destruction efficiency of 95 percent. As the value of energy increases, numerous ways have been employed to recover that energy. Table No. 2 is a list of energy recovery systems in common use.

Table No. 2 – Energy Recovery Systems

<u>Typical Systems used for Landfill Gas Energy Recovery</u>
Direct use in Boilers, Space Heat or Industrial Furnaces
Electrical Generation in IC Engine
Prepare Landfill Quality Gas (Remove non-combustibles)
Prepare for Use in Vehicles
Use as Feedstock to make Methanol

The 1990 Law added control of toxic air pollutants to the scope of air management goals. For landfills, trace organics that were listed toxic constituents, had to be measured and eliminated consistent with *de-minimus* emissions. The threshold was set at 10 tons per year for a single constituent and 25 tons per year cumulative for all constituents. Even for concentrations in the PPMV range of a toxic constituent, a large landfill could be snared into air toxic compliance requirements.

Law of Unintended Consequences

Throughout the evolution of laws and regulations to “fix” one problem resulted in the creation of an unintended one. The first of these was the Environmental Policy Act of 1969, the Clean Air Act of 1970 and the Clean Water Act of 1972. To a lesser extent the 1899 Rivers and Harbors Act also had some influence on waste disposal.

Environmental Policy Act of 1969

This Act was the first set of requirements that moved beyond nuisance mitigation to humans and encompassed both land and water habitats. Alteration to the natural environment required total front-end planning and a projection of what impacts would result on the terrestrial and aquatic environments. The set of requirements eliminated disposal in marshes and wetlands well before the impact of leachate on groundwater quality was scientifically established. As recent as 1970 Dr. Roscoe Kandle, New Jersey Commissioner of Health, extolled the virtue of filling low areas with waste and the elimination of marshes that are breeding areas for mosquitoes. With one regulation the siting of a landfill was completely altered from the use of marginal land to use of higher value land.

Clean Air Amendments of 1970

Solid waste professionals frequently point to the potpourri of clean air requirements as an example of the implementation of requirements without the considering the consequences of the impact on either the land or the water environments. The early

regulations emphasized removal of particulate matter, and disposal of the removed PM often posed problems. Dry systems generally relied upon land disposal, mostly in monofills, but which were often dusty and dust nuisances. Wet systems, especially small wet scrubbers often discharged into municipal sewer systems greatly increasing the solid loading on the POTWs as well as substantially increasing maintenance on gravity systems and pumps.

Solid Waste Disposal Act of 1965 (PL 89-272)

The first Federal act that directly identified solid waste for regulation and control was very broad and did not contain any enforcement sections. It was the position of the federal government that solid waste regulation was the responsibility of the states and each should develop its own regulatory and enforcement laws and regulations. This Act did recognize the need for research and development and pursuant to the implementation more than 60 projects were funded. Included in the list of funded projects were the first in-depth studies of leachate and gas generation from sanitary landfills. Until this point in time information on sanitary landfilling was derived from landfills and investigations in the State of California. Because of the arid climate, both gas and leachate were not considered to be significant problems. As a result of the expanding use of the sanitary landfill method into wetter climates, the magnitude of potential leachate and gas generation problems became clear. This Act was the forerunner to the 1970 Resource Recovery Act and the 1976 Resource Conservation and Recovery Act, better known as RCRA.

Pennsylvania Act 241 (1968)

The Pennsylvania Solid Waste Management Act was the most significant single act that moved the state toward energy from landfill gas. Regulations that implemented this Act proceeded to enforce closure of open dumps and malfunctioning landfills. The State proceeded to close more than 1800 landfills and open dumps. Secondly the State mandated that all municipalities having a population density greater than 300 persons per square mile must prepare a 10 horizon solid waste management plan. The third result of Act 241 was the first set of rules and regulations that guided both construction and operation of sanitary landfills. Grants and general prodding focused planning at the county level of government, and as a result most planning districts were for a single county. The result of this planning activity was the permitting and construction of larger regional landfills that were of sufficient size to generate landfill gas at a rate where recovery today is both feasible and fiscally attractive.

Research and Development conducted with funding under the 1965 Solid Waste Disposal Act evolved the model (now the HELP Model) that predicted the adsorption capacity of municipal refuse, and led to an experimental period in the 1970 decade when

liquid waste could be placed in a landfill under the assumption that no leachate would be generated provided that the rate of vertical filling exceeded liquid plus precipitation inflow. California landfills were already making liquid placement in landfills a common practice, and for a short period of time Pennsylvania allowed this practice in landfills that has impermeable liners to collect and treat leachate.

1972 Clean Water Act (PL-92-500)

The Clean Water Act, while focusing upon discharges of liquids to surface and ground water, did exert some significant influence upon the practice of sanitary landfilling. The first impact was the expansion of the number of facilities that were constructed to provide service to small and large municipalities. The result of the increased number of treatment plants was generation of both raw and digested sludge, much of which is deposited in landfills. Sewage sludge, especially raw sludge provides moisture and nutrients that increase and accelerate the generation of methane gas in landfills.

A second and not so benign impact was the diversion of liquid waste into landfills when municipalities developed ordinances to regulate the pretreatment of industrial wastes. With no disposal restrictions on the liquid and semi-liquid wastes, landfills received a wide array of industrial wastes including solvents, pesticides, herbicides, hospital waste, and other potentially deleterious wastes. Unlined sites receiving these types of wastes often were added to the CERCLA or Superfund list in the 1980's.

1976 Resource Conservation and Recovery Act (RCRA)

RCRA or PL 94-580 was the most comprehensive law written to address the management of wastes upon the land. RCRA addressed with both hazardous and non-hazardous waste treatment, storage and disposal. Most widely used methods of management waste upon the land, including landfills, lagoons, land farming, and deep well injection became regulated. The law was subdivided into hazardous (Subtitle C) and non-hazardous (Subtitle D) requirements.

The Subtitle C regulations were extremely broad and specified control over not only disposal, but also storage of drums, storage in tanks, treatment of wastes including incineration and all recycling, recovery and reuse operations. All waste that were transported required transporters who were permitted and a comprehensive manifest system was used to monitor the transport and disposal of all hazardous wastes.

For non-hazardous wastes that were disposed of on the land, EPA was required to evaluate landfilling, and to prepare a criteria that could be used to classify a landfill as either acceptable for sanitary landfilling or to classify the facility as an open dump. After development of the criteria for classification as an open dump, a national survey identified almost 40,000 facilities that were substandard and were classified as a dump.

Hazardous and Solid Waste Amendments of 1984 (HSWA)

The 1976 RCRA law was vague relative to land disposal of waste and temporary landfill regulations were promulgated in 1982, pending passage of additional legislation. In 1984 the amendments to RCRA were passed and regulations that effectively changed design of both Subtitle C and D landfills became law. Requirements for use of composite liners, leachate monitoring and gas control were part of the new legislation. HSWA also banned disposal of liquids in landfills, and phased out these practices for period of several years. Regulations also identified constituents of concern in leachate and provided a list for testing. Subtitle D regulations essentially rendered the trench method of landfill operation unacceptable. In 1991 RCRA was again amended, and the principle focus of the amendment was to define the conditions of “financial assurance”. Post closure care was defined as no less than 30 years, and sufficient funds must be provided to operate the maintenance of the landfill during that period of time.

National Energy Act of 1978

As a result of the energy turmoil that persisted throughout the 1970 decade, Congress passed the National Energy Act in 1978. This Act consisted of five bills addressing different segments of energy policy.

1. Natural Gas Policy Act of 1978
2. Power Plant and Industrial Use Act of 1978
3. Public Utilities Regulatory Policy Act of 1978
4. National Energy Conservation Policy Act of 1978
5. Energy Tax Act of 1978

Of these acts the most relevant to landfill gas is the Public Utilities Regulatory Policy Act (PURPA), PURPA opened the electrical generation and distribution system to deregulation of utilities and opened service areas to competition, and also required utilities to purchase electricity from non-utility generators. The rate that the utility was obligated to pay was based upon a concept of “avoided costs”, a rate which was usually well below the market price.

The second portion of the National Energy Act is the Energy Tax Act that provided tax credits, investment credit and depreciation advantages for renewable sources of energy.

Comprehensive Environmental Response, Compensation and Liability Act (CERCLA Or Superfund)

Superfund regulations imposed remediation criteria on many sanitary landfills, especially those that caused ground water contamination from landfill operation. One

condition in CERCLA exempted non-containerized gas (landfill gas) from remediation and focused requirements for gas management upon air quality regulations. However, for landfills that were included on the list for which remediation will be required, development of landfill gas recovery and utilization programs was subject to another level of oversight and approval.

Pennsylvania Act 97 (1980)

In Pennsylvania, like many of the more populated states on the east coast, waste disposal was becoming a major issue in the late 70's. The Solid Waste Management Act required the Department of Environmental Resources (DER) to develop a state wide solid waste plan and further develop regulations to manage waste. The DER then asked local governments to develop solid waste plans. For the first time landfill developers were required to post Bonds or other forms of surety accepted by the state to cover closure, post-closure and remedial costs. The planning and regulations lead to increased reliance on regional landfills and in California landfill gas for beneficial use had begun.

Pennsylvania Act 101 (1987)

This Act is often thought of as Pennsylvania's start of mandated recycling. It did require all of its municipalities with a population of over 10,000 to recycle at least three items from a list of eight. This Act for the first time banned non-hazardous items from municipal landfills – tires, lead acid batteries and loads primarily composed of leaf waste. There was an extensive recycling grant program started and funded by a \$2.00 fee on every ton of waste disposed of in a Pennsylvania landfill. There were new oversight and costs from Act 101 for every landfill. There was a minimum \$1.00 per ton "Host Fee" required for "Host Municipalities". Landfills were now required to offer testing of drinking wells for all contiguous property owners. Host Municipalities could now have "Host Inspectors" visit the landfills as often as they wanted and the Host Municipality would receive 50% reimbursement for these costs from the state. As a result of more regulations and costs the trend toward larger regional landfills accelerated as Act 101 was implemented. Many of large national waste companies that owned landfills were beginning to see landfill gas beneficial use projects as a steady source of revenue, tax credits and positive public perception that would go on long after a landfill was closed.

Section 29 Tax Credits (1995)

If Agreements were executed with a third party by the end of 1995 there were tax credits available for beneficial use projects. These tax credits spawned one of the biggest development periods in the history of landfill gas green power.

Pennsylvania Act 90 (2002)

This Act is unique to Pennsylvania and was a legislative response to being the biggest disposer of out of state waste in the country. Pennsylvania already had the most expensive fee structure at its landfills in the country and this Act added \$4.00 per ton. The extra cost of disposal in Pennsylvania led to the development of large regional landfills in neighboring states. Most of the out of state waste disposed of in Pennsylvania is from New York City and New Jersey. In some of the neighboring states rail transfer stations have been developed to decrease the transportation costs through and around Pennsylvania. Many of these new "Green Field" landfills had landfill gas to energy projects from the beginning to help pay for and help sell the landfill to regulators and the local public.

Summary

As the cost of energy doubles or triples prices in very compressed periods of time, and the use of "green" energy becomes a high priority in the national psyche, landfill gas becomes a readily available renewable fuel that can fill a small niche. Landfill gas utilization has many positive attributes such as:

- It is renewable
- Development costs are competitive with fossil fuel acquisition
- Utilization can occur at the source
- Capture and destruction is already required
- Capture and use can be independent of the energy grid

Some negative aspects include:

- Well field management can be complex
- Production may have short term life
- Some pretreatment may be needed for selected systems
- Multiple regulatory agencies (air, solid waste, waste water, OSHA) will have oversight.

It must be remembered that a landfill is first and only a facility for disposal of solid wastes. Landfill gas is a result of the disposal function, and must be managed according to the prevailing regulations relevant to landfill permits. Any gas program used for energy recovery must fit within that landfill operation framework.

