ENERGY-FROM-WASTE (EfW) – LESSONS LEARNED FROM THREE DECADES OF EXPERIENCE IN THE UNITED STATES

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ABSTRACT

Producing and utilizing energy from the combustion of solid waste (energy from waste or EfW) is a concept which has been practiced in Europe since the turn of the last century. Prompted by a concern for groundwater quality and the scarcity of land for landfilling, many European countries and Japan embarked on massive construction programs for EfW programs in the 1960's. Transfer of this technology to North America first began in the late 1960's and early 1970's. In addition, many other projects were constructed applying American technology for preparing solid waste-based fuels. Most of these projects were not considered successful, however, because they were unable to overcome materials handling and boiler operations problems. In the wake of such issues, local government leaders became increasingly cautious when contemplating the funding construction of EfW projects.

This paper briefly addresses some of the reasons why EfW increased dramatically in the United States from the mid 1980's to 2000. Since that time period, few EfW facilities have been expanded and fewer still new facilities constructed in the United States. The author provides some lessons learned from 30 years of EfW experience in the United States for waste managers in developing nations considering construction of new EfW facilities.

KEY WORDS

Energy from waste (EfW), waste-to-energy (WTE), incineration, resource recovery, waste conversion

INTRODUCTION

Prompted by a concern for groundwater quality and the scarcity of land for landfilling, many European countries and Japan embarked on massive construction programs for EfW programs in the 1960's. Transfer of this technology to the United States first began in the late 1960's and early 1970's. Most of these projects were not considered successful, however, because they were unable to overcome materials handling and boiler operations problems. In the wake of such

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issues, local government leaders became increasingly cautious when contemplating the funding construction of EfW projects. Nevertheless, several EfW projects were developed in the mid to late 1970's in communities such as Saugus, Massachusetts; Pinellas County, Florida; and Ames, Iowa, which were experiencing severe landfill problems. Success of these projects helped the EfW industry gain acceptance by local government leaders, and the financial community. Tax incentives made available by the federal government for EfW projects attracted private capital investment in such projects assisting in the maturing of this industry in the United States, and sparked the development of many new projects.

BRIEF HISTORY OF EFW IN THE UNITED STATES

As of this writing, the United States has 80 operating EfW plants[2] that generate approximately 2,769 megawatts, or about 0.4 percent of the nation's power production. In 2014, the United States combusted about 96,000 tons of municipal solid waste (MSW) daily or 29 million tons annually of MSW for energy production, or about 12 percent of all MSW. This is roughly equivalent to supplying 14.5 million megawatt-hours. Further, these plants are recovering about 730,000 tons of ferrous and non-ferrous metals annually.

In recent years, new EfW capacity was added to existing projects in Florida, Hawaii, and Minnesota. The first new facility in well over two decades is currently being constructed in Palm Beach County, Florida (3,000 tons per day). Nonetheless, these expansions and new construction are relatively minor when compared to the volume of post-recycling MSW requiring disposal in the United States.

What factors prompted the early successes in the EfW industry in the United States and led to its decline over the last two decades?

Federal Law: The Clean Air Act

The Clean Air Act (CAA) is legislation promulgated by the U.S. Congress to reduce the emissions of particulates and gaseous contributions to air pollution on a national level. It requires the U.S. Environmental Protection Agency (EPA) to develop and enforce regulations to protect the public from airborne contaminants known to be hazardous to human health and the environment. Major amendments to the law, requiring increasingly stringent regulatory controls for air pollution, passed in 1970, 1977 and 1990.

Section 129 of the Clean Air Act (CAA) authorizes the EPA to issue emission regulations for a range of both mobile and stationary emission sources, including solid waste incinerators. Emission regulations specifically directed at the larger solid waste combustors were issued during the 1980s and 1990s, and defined the pollutants to be regulated and the limits of discharges of those pollutants into the atmosphere. The regulations also proscribed which control technologies would be used. The EPA has subsequently promulgated regulations addressing concerns about emissions from smaller solid waste combustion units. EfW facilities have complied with very stringent EPA regulations, known as Maximum Achievable Control Technology (MACT), at an estimated cost of over US$1 billion.

[2] Four plants in the United States are deemed inactive.

Rising Energy Rates

Prior to the Arab Oil Embargo in 1973, most EfW plants in the United States recovered little or no thermal energy, except for internal plant needs. The worldwide increase in energy costs after 1973 made energy recovery from solid waste an economically viable option. Many American cities, which once had established steam distribution (district heating) systems for their downtown areas, but abandoned them in the era of cheap energy, began to seriously consider the redevelopment of these systems. The combustible fraction of MSW began to be considered as an energy source for the production of steam and electric power for use by local or widely distributed customers.

Public Utilities Regulatory Policies Act (PURPA)

Prior to the enactment in the USA of the Public Utilities Regulatory Policies Act of 1978, commonly known as PURPA, EfW facilities seeking to sell their surplus power to public or investor-owned utilities faced significant obstacles. For example, many utilities refused to purchase electricity from such producers or offered to purchase power at low-than-market rates. In addition, some utilities charged discriminatorily high rates for back-up electric service.

In order to conserve oil and natural gas, the U.S. Congress enacted PURPA with the objective of removing obstacles for facilities which generated electricity from alternative fuels such as solid waste, wood waste and biomass. Under Section 201 of PURPA, electric utilities were required to provide electric service to "qualifying facilities" at rates which are "just and reasonable, in the public interest, and which do not discriminate against cogenerators and small power producers. Qualifying facilities (QFs) were defined under the Act in two categories--small power production facilities and cogeneration facilities. A small power production facility is one which produces less than 80 megawatts of electricity from biomass, waste, or renewable resource fuel constituting more than 50 percent of the total energy source. Non-renewable fuel sources, such as oil, natural gas, or coal, cannot constitute more than 25 percent of the total energy input of the QF during any year.

Federal Tax Legislation

In 1986, United States tax law was altered to allow the issuance of industrial development bonds (IDBs) to finance the construction of EfW facilities if one of the following conditions applied to a project:

- Energy (steam, electricity, or recovered materials) is sold to a taxable entity such as an investor-owned utility or private company; or
- A private contractor operates the project with a contract duration in excess of five years; or
- A private contractor bears a "risk of loss" for situations beyond its control; or
- Solid waste is delivered by private haulers (not agents of the government) and their revenues account for more than 25 percent of the total project revenues.

IDBs for publicly-owned, EfW projects were considered tax-exempt if 95 percent of the bond proceeds are used for the solid waste disposal portion of the project. Under the so-called "95/5 rule," expenses for the construction or installation of equipment related to the sale of byproducts from the plant (steam, electricity, or recovered materials) are non-exempt. Therefore, these expenses, which are typically 10 to 15 percent of the total project cost, must be financed with taxable debt.

In 2008, tax credits were made available for private developers of EfW facilities in the United States. New portions of the tax code provide a tax credit for the production of electricity from various facilities that derive energy from various sources, such as wind, closed-loop biomass, open-loop biomass, geothermal resources, solar panels, small irrigation power plants, municipal solid waste and refined coal. The production tax credit (PTC) gives a taxpayer a federal tax credit of US$0.021 per kilowatt of electricity generated at a qualified facility in the first 10 years of operation. To qualify, such a facility must be owned and operated by the taxpayer, but the electrical power must be sold to an unrelated person.

The "Garbage Barge"

The Mobro 4000 was a barge (aka "Garbage Barge") used for hauling the same load of municipal solid waste (MSW) along the east coast of North America from New York to Belize and back until a location was found to off-load and dispose of the garbage. The barge proceeded along the coast looking for another place to offload but still continued to meet stiff resistance at each prospective disposal location. It made it as far south as Belize, again being rejected, before returning to New York. Upon arrival it was met with a heated legal battle preventing it from docking. The trash was finally incinerated at a New York facility, and the ash was buried where it originated.

At the time, the "Garbage Barge"incident was widely cited by environmentalists and the media as emblematic of the solid-waste disposal crisis in the United States due to a shortage of landfill space (particularly on the landfill-scarce East Coast) since almost 3,000 municipal landfills had closed between 1982 and 1987. It triggered much national public discussion about waste disposal, and is widely considered as an impetus for new EfW projects in many regions in the United States throughout the 1980s.

Federal and State Solid Waste Rules

The first federal legislation addressing solid waste management was the Solid Waste Disposal Act of 1965 (SWDA) that created a federal office for the development of national solid waste processing and standards and the support of research for improvements in MSW management. By the mid-1970s, all states had some type of solid waste management regulations that were at least as stringent as the federal rules. In 1976, the U.S. House of Representatives passed the Resource Conservation and Recovery Act (RCRA) that dramatically expanded the federal government's role in managing waste disposal. RCRA divided wastes into hazardous and non-hazardous categories, and directed the EPA to develop design and operational standards for sanitary landfills and close or upgrade existing open dumps that did not meet the sanitary landfill standards.

In 1979, the EPA developed criteria for sanitary landfills that included siting restrictions in floodplains; endangered species protection; surface water protection; groundwater protection; disease and vector (rodents, birds, insects) control; opening burning prohibitions; explosive gas (methane) control; fire prevention through the use of cover materials; and prevention of bird hazards to aircraft. In 1991, the EPA established new federal standards for municipal solid waste landfills that updated location and operation standards, added design standards, groundwater monitoring requirements, corrective action requirements for known environmental releases, closure and post-closure requirements and financial assurances to pay for future landfill care and maintenance over a 30 year horizon.

Siting Problems

The siting of a major public facility, especially an EfW project in the United States, is not a simple task, particularly when such facilities are often located in highly developed and environmentally conscious communities. Many technical, environmental, and social (institutional) issues must be considered. The site selection process is complex, requiring the project developer to not only identify a site that minimizes adverse environmental impacts and can accommodate the operation of a EfW facility, but also requires the development of specific site evaluation criteria that have a reasonable chance of public acceptance. To achieve this latter objective, the site evaluation criteria so devised must be well-documented and carried out in a uniform and consistent manner.

NIMBY (an acronym for the phrase "Not In My Back Yard"), or Nimby, is a pejorative characterization of opposition by residents to a proposal for a new development because it is close to them, often with the connotation that such residents believe that the developments are needed in society, but should be further away. (Of course, there are no places that are sufficiently far away from population centers to please everyone.).

Many local permitting agencies in the United States have required the use of environmental impact reports/assessments as a means to identify potential EfW facility siting concerns. In reality, these assessments have ended up as a vehicle that vocal opponents of these projects have used to delay, if not outright block development of necessary facilities. Some observers have termed this as "paralysis by analysis".

Flow Control

One of the more critical issues facing public officials pursuing EfW facilities is what is commonly termed, "waste flow control." In essence, each community must be able to assure those who will own its EfW facility and the financial underwriters for such a project that the solid waste generated from residential, commercial, and industrial establishments within the community will be available on a long-term basis to supply an EfW facility with fuel. Without explicit control (ownership) of the solid waste stream, there is the potential for diversion of solid waste from the community's facility. This would be an unacceptable situation because the revenues from tipping fees and the sale of electricity, steam, or recovered materials are used to finance the construction and long-term operation of such facilities, and the repayment of bonds or loans.

Waste stream control has been an issue of controversy in recent years in the United States between the EfW industry and local governments on one hand, and the solid waste haulers and the waste recycling industry on the other hand. This latter group has argued against the imposition of monopolistic waste flow control by local government for EfW facilities since this would interfere with interstate commerce and severely restrict their long-term financial liability by restricting their continued access to recyclable materials taken from the waste stream. Representatives for groups favoring recycling over energy recovery have asserted that recycling of materials from a community's waste stream would be beneficial rather than detrimental to the financial integrity of EfW facilities because the size and capital costs of such facilities could be reduced through initiation of flow reduction programs.

Many municipalities and stakeholders, including the investment community, have rejected this argument; representatives for these groups have argued that the financing of EfW facilities cannot take place without the long-term assurance on the part of government that a community's solid waste is committed for delivery to the EfW facility. Without such assurance, the investment community has asserted that the interest rate for project financing would increase dramatically. Furthermore, some representatives of local government have asserted their rights to prohibit scavenging of materials at the curbside because of public health and safety considerations. In recent years, some communities in the United States have attempted to take a middle course by enacting waste flow ordinances with commitment for EfW facilities, while at the same time encouraging the development of a strong recycling industry in their community. In most instances, experience has shown that waste reduction and the development of EfW projects are not necessarily incompatible.

Mechanical Processing and Design Issues

Throughout the 1970's and 1980's, a variety of EfW faculties were constructed in the United States by some of the largest Fortune 500 manufacturers and waste vendors (Carborundum, Combustion Engineering, Monsanto, Occidental Petroleum, Union Carbide, Dravo, Waste Management, and Westinghouse). These included such technologies as pyrolysis and refuse-derived fuel (RDF). Practically all of these relied on unproven, experimental, or emerging technologies that soon faced major operational process scale-up issues that oftentimes perplexed the design engineers and almost always led to costlier than anticipated operations. This included materials handling issues, more abrasive conditions of the waste feedstock, blockages, enhanced corrosion of boiler materials, and reduced throughput and energy output. When many of these issues were resolved in the field others cropped up. The end result is that the financial projections were not achieved and most of these were shuttered. A few sites were later reused for construction of mass-burn EfW facilities in a few municipalities.

Financial Mismanagement

Technology and design issues were not the only remaining issues to be resolved for many EfW facilities in the United States. Even for those which utilized tried and tested EfW technologies, many facilities experienced financial mismanagement in most cases by the municipal owners who clung to an unproven philosophy that there is "Gold in Garbage." A good example of this municipal malfeasance is the problem-prone Harrisburg, Pennsylvania, EfW facility, which almost drove the City to insolvency.

The mass burn EfW facility in Harrisburg was constructed in 1972, but fell out of compliance with federal regulations in the 1990s. In 2003, the City decided to overhaul and expand the plant that already had over US$100 million of outstanding debt. City officials and advisers knew there was "substantial risk" that the facility could not repay its debt and proceeded with bond financing for reconstruction.

Briefly, reconstruction costs exceeded estimates, the original contractor was fired, and taxpayers ended up owing more than US$300 million for a project that was supposed to cost US$64.2 million and generate a total surplus of US$57.4 million by 2028. After many years of bankruptcy litigation, the facility was sold to a neighboring solid waste authority in 2014. Bond repayments are assured from City solid waste tipping fees, energy revenues, and parking fees and fines within the City. All of these rates have escalated dramatically for local residents to pay back the debt service, which now may exceed US$1 billion.

CONCLUSION

The development and sustained operations of EfW facilities in the United States have followed a tortuous path over the past three decades. At its peak period of construction in the late 1980s, some observers predicted construction of well over 500 EfW facilities, making it the predominant form of waste volume reduction in the United States. This paper sets forth some of the many issues that have limited EfW construction in the United States with only 80 plants in operation at the time of this writing, with more than 90% of those plants located east of the Mississippi River.

The author's 36 year experience in this field in the United States suggests that those seeking to advocate for EfW facilities in their nations should consider the enactment of national legislation or policies as noted below. These would mitigate some of the problems that the EfW industry has faced in the United States, enhance environmental sustainability, and minimize overall financial costs for waste disposal.

Stringent Landfill Regulations/Bans

In Europe, the bans on organics (combustible materials) from landfills and high tipping fees/taxes imposed by the European Union (EU) have effectively resulted in the diversion of this fraction of MSW from landfills and widespread support of the construction of new and expanded EfW facilities. As an example, Sweden's tax on waste sent to landfills is currently 435 SEK per ton, roughly equivalent to US$67 a ton (2014). A landfill penalty at this level certainly is sufficient to justify a Swedish city's investment in otherwise costly EfW technology.

In the United States, there is currently no Federal landfill tax or a ban on landfilling. There are, however, several municipalities that have imposed a "landfill tax." For example, the city of San Jose, California, has enacted a relatively low landfill tax of US$13 per ton (which significantly less than Sweden's landfill tax).

For most regions of the United States, however, landfilling is still less costly than EfW because they are blessed with sufficiently remote land to site and operate landfills. Further, current GHG rules imposed by the USEPA and state regulators are still relatively benign in terms of longterms of impacts upon long-term operating costs. Consequently, the differential in tipping fees of landfilling versus EfW is still a major impediment to implementation for most communities.

Placing a Tax on Carbon

EfW has been recognized internationally as a powerful tool to reduce the emission of greenhouse gases (GHG) as a means of mitigating climate change. The International Panel on Climate Change (IPCC), the Nobel Prize winning independent panel of scientific and technical experts, has recognized EfW as the key greenhouse gas emission mitigation technology. The World Economic Forum, in its 2009 report, *Green Investing: Towards a Clean Energy Infrastructure*, identifies EfW as one of the eight technologies likely to make a meaningful contribution to a future, low-carbon energy system. In the EU, EfW facilities are not required to have a permit or credits for emissions of CO_2 because of their inherent greenhouse gas mitigation potential.

Recognize EfW As Renewable Energy

A typical EfW plant is able to generate about 550 kilowatt-hours per ton of waste while complying with all state and federal standards. This process has led many to recognize EfW facilities as a form of renewable-energy technology.

States' adoption of renewable-energy standards, which require electric-utility companies to produce a portion of their electricity from renewable resources, has considerably driven clean energy advances in recent years. The 29 states and the District of Columbia that have such standards also include landfill gas as an eligible technology, but only 21 states and the District of Columbia recognize EfW as an eligible technology. Maryland has shown the most leadership in this regard by raising EfW from a Tier II to a Tier I technology—the same level that solar and wind energy are on in the renewable portfolio standard, which will increase the percentage of renewable energy from EfW plants allowed in states' portfolio standards. Other states (and even developing nations) should look to Maryland and Connecticut and adopt similar policies or seek to modify existing waste-management policies so as to reduce incentives for and reliance on landfills and complement their renewable portfolio standard goals.

Favorable Tax and Revenue Policies

EfW is a capital intensive technology relative to other solid waste management alternatives. Government entities can support such projects through the implementation of accelerated depreciation allowances for equipment, sales taxes exemptions, low-interest loans for developers, tax credits, energy production grants, tax exempt bond funds, and preferential feed-in electricity tariffs. Many of these measures were applied effectively during the peak of the EfW construction period in the United States.

Use of EfW Energy for District Heating

EfW is more efficient at producing heat energy than electricity. The fundamental idea behind district heating or cooling (DHC) is relatively simple – combining together multiple energy consumers through a piping network, typically underground. However, recovery of district heat for useful purposes requires large investments in energy infrastructure (district heating pipes distribution and transmission network), and the lack of such infrastructure makes combined heat and power difficult in many locations.

In Denmark, waste incineration has been used to provide district heating since 1903. The incineration plant of the municipality provided steam, hot water, and some electricity to a nearby hospital, while reducing the waste volume and mass at the same time. From the late 1980s, EfW plants in Denmark started to produce combined heat and power (CHP).

In general, the efficiency of energy recovery in district heating EfW plants is three- to five times higher than from electricity-only plants. Additionally, the revenues from selling district heat generated at an EfW plant may substantially reduce the overall facility tipping fee. For example, in 2007, 70% of the costs of the 29 Danish WTE plants were recovered by revenues from selling district heat.

A viable alternative to DHC in many locations is to distribute electricity to adjacent buildings in a campus-wide setting. As part of its plant expansion in 2009, Hillsborough County, Florida, (Tampa metropolitan area), initiated plans to transmit electricity to an adjacent regional wastewater treatment plant, which is allowed under Federal and state regulations. This enables the County to save about US$250,000 per year. Future plans are to expand the campus electricity distribution network to reach the adjacent county jail, an animal services building and a County warehouse complex.

Developing Public Support for EfW

Since the inception of the modern age of EfW in the United States, hard questions have been raised about the safety of technologies and their operations. These questions have come from governmental regulatory and public health agencies, as well as anti-EfW activists and the general public. Unfortunately, these questions are oftentimes mixed with unsubstantiated statements being expressed in public meetings and the media about increased cancer risks and other health issues, increased noise, odors, traffic, and the loss of property values. The agency or developer proposing the EfW plant is then asked to refute these assertions by the opposition groups and usually engages experts to conduct studies such as health risk assessments, traffic studies, and property valuations. Unfortunately, the activists usually dismiss these studies as being biased. That being said, legal maneuverings often transpire causing much public distrust and animosity between both sides in these EfW projects.

Have we learned a better way to advance the application of EfW based on three decades of experience with EfW facilities in the United States? If I had a magic wand, I would form and empower an independent agency to collect long-term data and information about the operations, reliability, impacts, and economics at existing EfW plants. This agency and its experts would serve as an "honest broker" by the public to provide critical yet objective evaluations and predictions about the potential operation of a proposed EfW facility, and reduce if not eliminate the costly and divisive public controversies that have plagued the industry (at least in the USA) for decades.

REFERENCES

1. Chrostowski, P.C. and Foster, S.A. (2014).*Resolution of a Controversy–Do Waste to Energy Plants Cause Public Health Impacts*? Proc.29th International Conference on Solid Waste Technology and Management, Philadelphia, PA. pp 252-263.
2. Kleis H, Dalager S (2004), *100 years of waste incineration in Denmark.* Babcock and Wilcox, Vølund and Ramboll, Copenhagen, 2004.
3. Michaels, T., (2014) *ERC Directory of Waste-To-Energy Facilities*, Energy Recovery Council.
4. Rogoff, M.J. and F. Screve, (2011), *Waste-to Energy Technologies and Project Implementation*, William Andrews/Elsevier, Waltham, MA, 2011
5. Stoller, P.J. and W.R. Niessen, (2009) *Lessons learned from the 1970s Experiments in solid Waste Conversion Technologies*, NAWTEC 17-2348.