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ENERGY RECOVERY FROM MUNICIPAL SOLID WASTE IN CALIFORNIA: NEEDS AND CHALLENGES

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ABSTRACT

Thermal technologies, such as gasification, pyrolysis, waste-to-energy (WTE), and advanced thermal recycling (second generation WTE with the most advanced air emission control system), can be employed to recover energy from municipal solid waste (MSW), reduce the volume of material to be landfilled, and lessen the potential emission of methane. Methane is a potent greenhouse gas and a major component of landfill gas.

All operating WTE facilities in the United States have been subjected to strict environmental regulations since the passage of the Clean Air Act Amendments in 1990. As a result, U.S. WTE facilities now meet or exceed stringent local air quality standards, including those imposed by the South Coast Air Quality Management District (SCAQMD) in Southern California.

The United States Environmental Protection Agency (EPA) recognizes the important role of WTE in the integrated solid waste management and ranks combustion higher than landfilling in its solid waste management hierarchy. In addition to upstream source reduction and recycling, downstream thermal treatment of the residual MSW (conducted in controlled environment) can effectively recover energy and further reduce waste volume.

Despite all the advantages and environmental benefits of thermal technologies, its utilization for treating MSW in California still faces many challenges. These include negative public perceptions, economical disadvantages, local marketability of by-products, and disposal options for residuals.

This paper discusses the need to include energy recovery in the integrated MSW management in California and the challenges encountered by many local jurisdictions.

INTRODUCTION

Over the last two decades, many jurisdictions in the State of California have made tremendous progress towards diverting solid waste from landfills. In 2008, California has achieved an estimated statewide diversion rate of 59 percent [1], significantly surpassing the 50% diversion by 2000 mandate under the landmark Integrated Waste Management Act of 1989 (Assembly Bill (AB) 939).

In spite of all these efforts, California still disposes an estimated 40 million tons of waste at landfills each year [2]. Approximately 70% of this landfilled waste is organic (57% biomass and 13% plastics/textiles) [3]. This abundant amount of organic waste is a potential source of energy for the state, which has a growing demand for renewable power [4].

In California, there are only three operating waste-to-energy (WTE) plants for MSW, namely, the Commerce Refuse-to-Energy Facility (CREF, Commerce), the Stanislaus County Resource Recovery Facility (SRRF, Crow's Landing), and the Southeast Resource Recovery Facility (SERRF, Long Beach). The three facilities collectively processed approximately 790,000 tons of MSW in 2008. This represents only 2% of the total post-recycled waste generated in the state (36,376,000 tons), while the other 98% was disposed at solid waste landfills [5].

In 2007, there were reported 87 WTE facilities operating in 25 US states [6]. In 2008, these facilities processed a combined total of nearly 32 million tons of MSW, or almost 20% of the total waste discarded after recovery (166.7 million tons) [7].

Many local jurisdictions in California are exploring available and proven alternative technologies to lessen their dependency on landfills. For example, the City of Los Angeles, is evaluating technologies (includes thermal and biological technologies) to treat post-source separated MSW, and recover energy and other resources. Other municipalities, including the County of Los Angeles and the City of Sacramento, are also investigating these technologies. It is important to examine the niche and role of WTE in solid waste management plans in the Golden State as they have been successfully implemented and are safely operating in many US states, including California.

This paper discusses the need to include energy recovery technologies as part of the California's integrated MSW management hierarchy and the related challenges encountered by many local jurisdictions.

THE NEED FOR ENERGY RECOVERY TECHNOLOGIES IN CALIFORNIA

California may utilize thermal technologies to fulfill their need to manage MSW, address the landfill crisis, recover additional recyclable materials, recover energy, reduce greenhouse gas (GHG) emissions, achieve renewable energy portfolio standards, and increase local employment opportunities.

Landfill Crisis

A driving force behind AB 939 was the realization that California's remaining landfills would soon reach their full capacity. It is estimated that California has 30-55 years of remaining landfill capacity [8]. Many metropolitan areas are expected to reach their landfill capacity much sooner. These values will greatly depend on disposal rates and population growth.

In Southern California, the landfill crisis is imminent as most of the active landfills are scheduled to close within the next two decades [9]. There are no new urban landfills being sited in the Los Angeles County (LAC), and no other operating landfills in the LAC have enough capacity or are being permitted to increase their capacity [10]. In the event that new landfill sites are identified, it is estimated to take at least 15 years to complete the permitting process, which includes an environmental review, community outreach, responses to legal challenges, and processing time [11].

A major landfill servicing the LAC jurisdiction is the Puente Hills landfill, which accepts approximately 4 million tons, or more than two-thirds of the waste generated per year in the LAC. This landfill is set to close on October 31, 2013 [10]. To replace local, urban landfills as they reach capacities and close, the Los Angeles County Sanitation Districts (SAN Districts) is implementing the Waste-by-Rail system. The SAN Districts' plan is to rail haul residual waste from transfer stations or material recovery facilities to the Mesquite Regional Landfill (Imperial County) or Eagle Mountain Landfill (Riverside County), both of which are approximately 200 miles away from LAC, for disposal. The Mesquite Regional Landfill was purchased in 2002 by the SAN Districts and is fully permitted to accept residual waste transported from Southern California communities by rail. However, the purchase of Eagle Mountain Landfill and its eventual operation are contingent upon successful resolution of pending federal litigation. It is projected that the Waste-by-Rail system will begin operation in 2011/2012 [12].

Exporting waste to neighboring counties does not necessarily address the landfill crisis issue. In addition, construction of new landfills to meet the current waste disposal needs destroys natural resources for future generations.

Increased Recovery of Recyclables

Although California has surpassed the AB 939 50% landfill diversion by 2000 mandate, many local governments continue to aspire for higher diversion targets. The City of Los Angeles, for example, has reached a 65% landfill diversion rate and stays on course towards achieving 70% by 2013.

Incorporation of energy recovery technologies into a solid waste management plan may result in recovery of additional recyclable material from MSW destined to landfills. In some thermal conversion or refuse-derived fuel facilities, metals and other recyclables are removed from the MSW before combustion. In other WTE plants, which are not equipped with a pre-sorting station, non-ferrous and ferrous metals are recovered from the bottom ash. Annually, all WTE facilities in the US recover more than 700,000 tons of ferrous metals from the combustion ash [6].

Greenhouse Gas Emissions Reduction

In 2006, California's Global Warming Solutions Act of 2006 (AB 32) was signed into law and set the state's GHG reduction goals. Through AB 32, the California Air Resources Board (ARB) developed a scoping plan with goals to reduce the state's GHG emissions back to the 1990 level by 2020, and further reduce the 1990 level by 80% by 2050. Utilizing WTE facilities for waste disposal can help reach the AB 32 goals.

GHG emissions reduction from landfills has been identified in the scoping plan as one of the key measures in meeting the goals of AB 32 [13]. As shown in Figure 1, landfills, which fall under the recycling and waste management sector, contributed an estimated 6.3 $MMTCO_2E$ or approximately 1% of the California's total 2006 GHG emissions [14], and most landfills are equipped with gas collection systems to capture roughly 60-90% of the methane emitted, while the remaining portion escapes into the atmosphere [15]. However, in California, MSW landfills are the second largest anthropogenic source of methane [2]. It has been reported that processing MSW through WTE rather than disposing it into a landfill reduces GHG emissions by one ton of carbon dioxide (CO_2) per ton of MSW processed [16].

In addition, electricity generation is the second largest source of GHG emissions in California. As shown in Figure 1, electricity generation, which includes in-state and imports, accounts for an estimated 106 $MMTCO_2E$ or approximately 22% of the GHG emissions. In comparison to other fuel types, WTE facilities emit significantly less CO_2 than fossil fuel power plants (Table 1) since 67% of the CO_2 emissions from WTE facilities are biogenic [17].

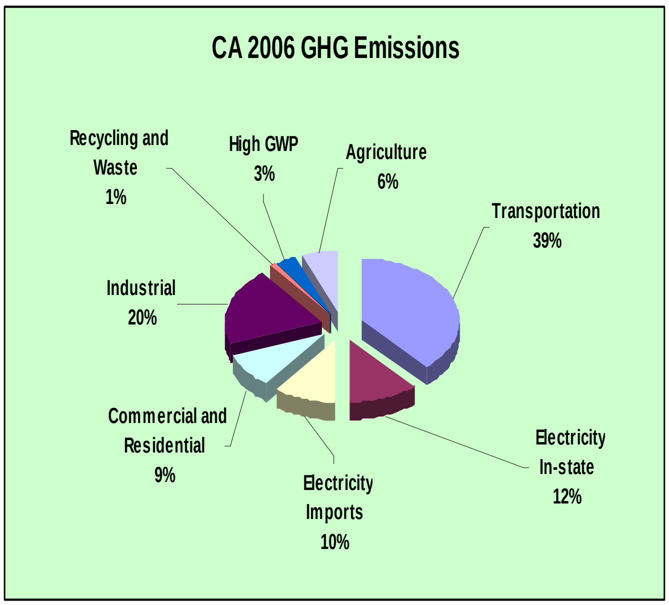

Figure 1. CA 2006 GHG Emissions by Sector [14]

Table 1. WTE and Fossil Fuel Power Plants CO_2 Emissions [18]

Fuel Type	CO_2 (lb/MWh)
MSW	837
Coal	2,249
Oil	1,672
Natural Gas	1,135

In a recent study of GHG emissions from WTE and landfills that took into consideration the gross GHG emissions and avoided emissions (electricity generation, metal recycling, landfill disposal), it has been estimated that 1.25 ton CO_2 equivalent is reduced per ton of MSW diverted from a landfill to a WTE facility [19].

Energy Production from Biomass

WTE facilities can also help reduce fossil fuel use and foreign oil dependence. Since these facilities operate continuously (24 hours per day, 7 days a week), they can provide base-load electricity to communities. Combusting one ton of MSW through WTE generates 550 kilowatt-hours of electricity (net), and avoids mining of a quarter of a ton of coal or the importation of one barrel of oil [16].

Renewable Portfolio Standard

In 2002, Senate Bill (SB) 1078 was passed to establish the California Renewable Portfolio Standard (RPS). The bill required Investor-Owned Utilities (IOUs) such as Southern California Edison, Pacific Gas & Electric (PG&E), and San Diego Gas & Electric to procure 20% of their retail sales from eligible renewable resources by 2017. Publicly Owned Utilities (POUs), including the Los Angeles Department of Water and Power, are required to implement and enforce their own RPS programs while not being subjected to the same requirements as IOUs. In 2006, SB 107 accelerated the requirement for IOUs to be reached by 2010 [20] and Governor Arnold Schwarzenegger issued his Executive Order S-06-06, which called for an increase in production and use of bioenergy with two specific targets [21]:

(1) Regarding biofuels, the state produce a minimum of 20 percent of its biofuels within California by 2010, 40 percent by 2020, and 75 percent by 2050, and

(2) Regarding the use of biomass for electricity, the state meet a 20 percent target within the established state goals for renewable generation for 2010.

In November 2008, the Governor signed the Executive Order S-14-08, which raised California's renewable energy goals to 33% by 2020 [22].

Federal law has recognized WTE facilities to be a source of renewable energy for more than 30 years. This recognition is further supported by 24 state governments and the District of Columbia, and through documents such as the Energy Policy Act of 2005, Public Utility Regulatory Policy Act of 1978, Biomass Research and Development Act of 2000, Pacific Northwest Power Planning and Conservation Act, Federal Power Act, and the Internal Revenue Code [23].

Increased Employment Opportunities

According to the US Bureau of Statistics, as of November 2009, the State of California has a 12.3% unemployment rate, which is the third highest in the nation, and higher than the national rate of 10% [24]. Construction of a 1,500 ton-per-day (tpd) WTE facility could provide 250 on site construction jobs for 3 years and 50 direct permanent positions [25]. A previous study also estimated nearly 14,000 primary jobs could be created if the 34 million tons per year of biomass in California were to be used for power generation [26]. Therefore, implementation of more WTE facilities in California can create job opportunities.

THE CHALLENGES TO IMPLEMENTING ENERGY RECOVERY FACILITIES IN CALIFORNIA

Despite the benefits of implementing WTE or other thermal technology facilities into a solid waste management plan, there are many hurdles that tend to preclude their construction, making the benefits difficult to attain. These challenges span environmental, social, and economical concerns.

Air Quality

The State of California is divided into 35 air districts called Air Pollution Control Districts or Air Quality Management Districts. These agencies are county or regional governing authorities that are primarily responsible for controlling air pollution from stationary sources [27]. Sources of pollution (i.e., facility) will be governed by the rules and regulations of their given air district. For instance, a WTE facility located in the Los Angeles area is within the South Coast Air Basin and would adhere to the SCAQMD's rules and regulations. Under the SCAQMD's New Source Review, any new WTE facility sited in the area will be required to have the Best Available Control Technology to mitigate emissions. Furthermore, since the basin has also been designated as a non-attainment area for ozone and its precursors (i.e., Nitrogen Oxides (NO_x), Sulfur Oxides (SO_x), Volatile Organic Compounds (VOCs), and Particulate Matter (PM)), stricter emission limits may be applied to the facility in comparison to other air basins.

In addition, the SCAQMD may require the facility to provide Emission Reduction Credits (ERCs) to offset the facility's emissions. ERCs for NO_x, SO_x, PM, and VOCs can be purchased in the open market or obtained from SCAQMD's internal credit bank.

Ash Disposal and Reuse

WTE facilities with resource recovery generate ash (bottom and fly). In accordance to Federal law, the ash is tested to ensure that it does not exhibit any Toxicity Characteristics. Therefore, WTE facilities perform and pass the Toxicity Characteristic Leaching Procedure (TCLP) to demonstrate that the ash generated is non-hazardous [28]. Over the years, ash generated from WTE facilities has consistently passed the TCLP, and proves that it is safe for disposal and reuse [29].

In California, ash from WTE facilities must also pass an additional compulsory test called the Waste Extraction Test (WET) to assess whether the ash generated is hazardous. The WET is a leaching extraction test developed by the California Department of Toxic Substances Control. The WET uses citric acid as the extraction fluid, rather than acetic acid used in the TCLP, making it a more stringent and aggressive test to pass. In addition, the WET requires a 10-fold dilution ratio (ratio of the solid portion of the waste to the extractant fluid), while the TCLP requires a 20-fold dilution ratio [30].

Aside from passing the threshold limits of the WET, any new WTE facility in California has to consider whether the ash generated can be beneficially reused or would need to be disposed and its related costs. Currently, California has no existing regulatory framework for reuse of ash as aggregate, and there is limited availability of landfills permitted to accept bottom and fly ash. In comparison, some other US states have ash disposal and reuse regulations in place.

Renewable Portfolio Standard

In 2008, California obtained 10.61% of its total system power from renewable sources, which included 2.08% from biomass [31]. Despite the role of biomass in power generation, according to current California statute, a WTE facility is recognized as a source of renewable energy if the following stipulations are met [32]:

(1) The facility is located in Stanislaus County, and
(2) It is operational prior to September 26, 1996.

While utility companies in California are required by SB 107 to procure 20% renewable energy by 2010, as well as the need to lower GHG emissions from the electricity generating sector, the above stipulations limit IOUs from tapping into WTE for RPS compliance. The only WTE facility in California that meets these stipulations is the SRRF, which sells its power to PG&E. These stipulations exclude any new or other existing WTE facilities from RPS eligibility; therefore, there is no incentive for IOUs to consider WTE facilities for RPS compliance.

However, POUs may utilize energy from WTE facilities for RPS compliance if their respective governing board defines this source as a renewable energy. Unfortunately, no POUs have adopted this definition.

Public Perception

Despite the successful operation of 87 rule-compliant WTE plants in many US States, including the three California facilities, public dissonance against WTE remains strong and hinders the development of more WTE facilities. It has been next to impossible to install new WTE facilities in California during the last few decades. Most public concerns focus on how WTE may affect existing recycling programs, what types of air pollutants are emitted from WTE, and the potential public health effects from the disposed combustion ash.

There is a prevalent misconception among the public that WTE facilities compete with traditional recycling practices and initiatives, and therefore, are detrimental to increasing the state's landfill diversion rates. In practice, some WTE facilities presort the MSW to recover recyclable materials such as glass and metals prior to the thermal treatment, and in doing so, also improves the fuel characteristics of the remaining MSW [33]. In addition, many WTE facilities recover ferrous and non-ferrous metals from the combustion ash residue [34]. In a recent study, Dr. Eileen Berenyi found recycling rates to be five percentage points or more higher than the national average in communities with WTE facilities (Figure 2).

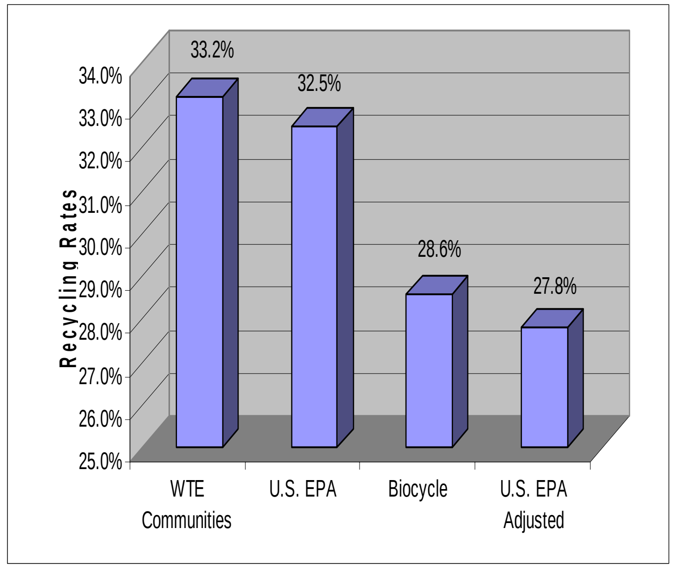

Figure 2. Comparison of WTE Communities' Recycling Rate with National Rates [35]

Moreover, the Confederation of European Waste-to-Energy Plants has reported that Germany, Belgium, and the Netherlands, countries who have most successfully reduced landfill dependence and with the highest recycling rates among European countries in 2007, have done this with WTE as one of their solid waste disposal options (Figure 3). Therefore, the recycling programs and WTE facilities can co-exist in a solid waste management plan, so much that they complement each other rather than compete.

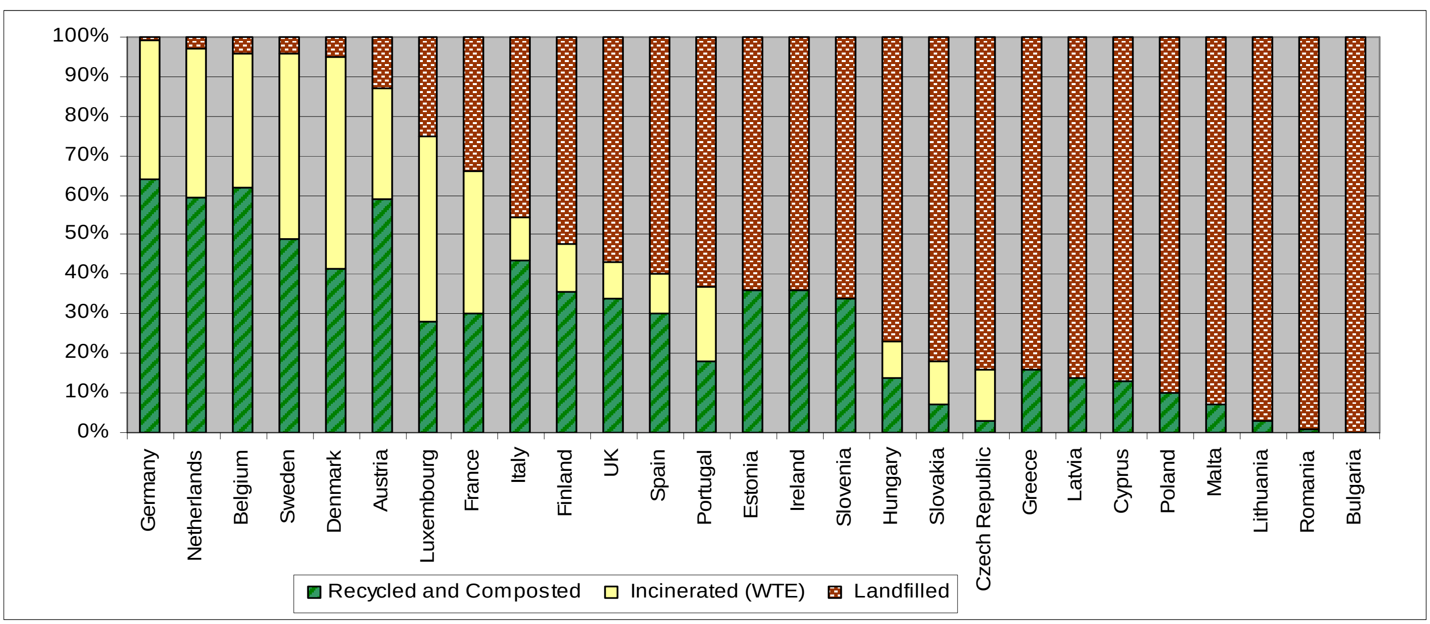

Figure 3. 2007 Treatment of MSW in Europe [36]

Besides being perceived to compete with recycling programs, WTE facilities continue to carry the stigma of being a major source of air pollutants. In the past, incinerators were not equipped with air emission controls; many became concerned over the negative impacts that these pollutants have on public health. Recognizing the need for more stringent air emission controls, in 1995, the US EPA implemented new emissions standards for WTE plants. WTE facilities are now required to comply with the maximum achievable control technology (MACT) regulations, and as a result, emissions from WTE facilities have drastically decreased (Table 2) [37].

Table 2. Emissions from Large and Small Municipal Waste Combustor Units [37]

Pollutant	1990 Emissions (tons/yr)	2005 Emissions (tons/yr)	Percent Reduction
CDD/CDF, TEQ basis[1]	4,400[2]	15.0[2]	99+%
Mercury	57	2.3	96%
Cadmium	9.6	0.4	96%
Lead	170	5.5	97%
Particulate Matter	18,600	780	96%
HCl	57,400	3,200	94%
SO_2	38,300	4,600	88%
NO_x	64,900	49,500	24%

In a recent study, an estimated assessment was made between the health risks associated with landfilling and WTE combustion [38]. In addition to the air quality impacts from the landfill or the facility itself, the study accounted for the impacts stemming from the transport of the material to its final destination (landfill or WTE facility), the use of transfer stations, and in the case of a WTE facility, transport of WTE combustion ash to a landfill. The overall individual cancer and non-cancer risks related to landfill disposal was found to be five times higher than the risks related to WTE combustion [38].

Even if jurisdictions continue to reduce their reliance on their local, urban landfills but continue to use distant landfills as an alternative, the long-range transport of the MSW results in increased emissions from diesel-powered vehicles. This leads to an increase in emissions of GHGs and diesel-fueled engine exhaust, which has been identified by the California Air Resources Board as a toxic air contaminant [39]. Therefore, relatively local handling of MSW must be considered in a waste management plan.

Furthermore, WTE facilities converting MSW to energy is shown to produce lower air emissions compared to coal-fired power plants. Table 3 compares the air emissions between coal-fired plants and WTE plants.

Table 3. Coal-Fired Plants vs. WTE Plants 2000 U.S. Emissions [40]

Pollutant	Coal-Fired Plants (in short tons)	WTE plants (in short tons)
SO_2	8,540,000	4,100
NO_x	3,660,000	46,500
HCl	320,700	2,670
Particulates	566,000	700
Lead	49	4.8
Mercury	48	2.2
Cadmium	35	0.35
Pollutant	**Coal-Fired Plants (g TEQ)***	**WTE Plants (gTEQ)***
Dioxins/furans	60	12
% of total reported dioxins	5	1

*g TEQ= grams of toxic equivalent dioxins/furans

Another public concern is the potential public health impact of contaminated leachate from landfills used for combustion ash disposal. In the case where the combustion ash is not beneficially reused, it may be disposed of into a permitted landfill. WTE generates two types of ash: bottom and fly ash. Bottom ash does not contain significant concentrations of metals and organic contaminants, and can be beneficially used in road construction. However, fly ash retains heavy metals, dioxins, and other undesirable contaminants and can be considered hazardous waste depending on test results [41]. In some cases, bottom and fly ash have been mixed to produce "combined ash", which is then used as alternate daily cover in landfills. While studies have indicated that leachate from ash landfills is not concentrated in heavy metals [42], efforts have been made to increase the recycling potential of these materials [38, 43].

<u>Cost</u>

Some European Union States impose landfill bans and higher taxes resulting to higher landfill tipping fees, to promote the use of WTE [44]. In California, such mechanisms are not in place, and any new alternative facility has to compete with the current landfill tipping fees and existing WTE fees in order to be an attractive option.

Currently, tipping fees at California landfills range from $22/ton to $68/ton and WTE fees range from $28/ton to $65/ton (Tables 4,5, &6).

[1] Dioxin/furan emissions in units of toxic equivalent quantity (TEQ), using 1989 NATO toxicity factors
[2] in grams/yr TEQ

Table 4. Southern California Landfill Tipping Fees [45]

Landfill	County	Tipping Fees ($/ton)
1. Puente Hills	Los Angeles	$38.26
2. Calabasas	Los Angeles	$40.82
3. Scholl Canyon	Los Angeles	$48.99
4. Sunshine Canyon	Los Angeles	$54.00[3]
5. Frank R. Bowerman	Orange	$46.00[4]
6. Olinda Alpha	Orange	$46.00[4]
7. Prima Deshecha	Orange	$46.00[4]
8. El Sobrante	Riverside	$34.37[5]
9. Simi Valley	Ventura	$50.00[6]
10. Miramar	San Diego	$40.00-54.00[7]

Table 5. Northern & Central California Landfill Tipping Fees

Landfill	County	Tipping Fees ($/ton)
1. Kiefer	Sacramento	$30.00[8]
2. Republic/Vasco Road	Alameda	$38.88[9]
3. Buena Vista Sanitary	Santa Cruz	$68.00[10]
4. Yolo County Central	Yolo	$40.00[11]
5. Cold Canyon	San Luis Obispo	$49.00[12]
6. City of Paso Robles	San Luis Obispo	$46.85[13]
7. American Avenue	Kern	$21.60[14]

Table 6. California WTE Tipping Fees [45]

Facility	County	Tipping Fees ($/ton)
1. SERRF	Los Angeles	$48.00
2. CREF	Los Angeles	$65.00
3. SRRF	Stanislaus	$28.00[15]

[3] Sunshine Canyon Landfill website
[4] OC Waste & Recycling website
[5] Riverside County Waste Management Department website
[6] WM-Ventura
[7] City of San Diego website
[8] Kiefer Landfill website
[9] Alameda County website
[10] Santa Cruz County website; with special conditions imposed
[11] Yolo County website
[12] Cold Canyon Landfill website, Fee for uncompacted waste
[13] City of Paso Robles website; Fee for uncompacted waste
[14] Fresno County website
[15] Waste received by the facility is restricted to the City of Modesto & Stanislaus County only; per personal communication, rates reflect the annual O&M fees in the exclusive contract between the facility & the respective municipalities.

If incentives were available to WTE facilities to offset their capital and operational costs, WTE tipping fees may be lowered, and thus become competitive with landfilling. One of the ways WTE facilities can reduce the tipping fee for MSW is by charging higher tipping fees for certified destruction services, such as processing confidential documents [46].

Siting

Many California municipalities have restrictions on the type of facilities that can be built within its boundaries, making the implementation of WTE facilities in these communities almost impossible. For example, the City of San Diego's Proposition H imposes the following stipulations to facilities that burn more than 500 tpd of solid waste [47]:

(1) No such facility shall be built that:

- will increase existing levels of toxic air pollutants within the City as those levels are determined by Federal, State, or San Diego public agencies;
- or be located within a 3-mile radius of a hospital, elementary school, child care center, or nursing home for the elderly licensed by a governmental entity;
- or make additional demands on the treated water distribution system within the City.

(2) Any such facility built shall include recycling and separation methods whereby major sources of toxic air pollutants including, but not limited to plastics, metals, industrial wastes, and coatings, are removed from the solid waste prior to incineration.

CONCLUSIONS

In many US states and other countries, WTE facilities have been successfully implemented to process post-recycled MSW, recover additional recyclable materials, and produce energy. WTE technologies can be an effective solid waste management tool. Inclusion of WTE to a solid waste management plan can decrease landfill reliance, mitigate climate change, lower the need of fossil fuel for energy generation, and reduce the health risks related to landfill disposal. Most notable, as a result of US EPA's MACT regulations, atmospheric emissions from WTE facilities have been significantly reduced.

Despite all of these environmental and economic benefits, public opposition is a key obstacle to implementing WTE facilities in California. There is a great need to educate the public on current thermal treatment technologies, and overcome their misconceptions. State environmental agencies need to become more active in educating the public on each municipal solid waste management option in order for the public to make informed decisions.

Successful incorporation of WTE facilities into local California jurisdictions' solid waste management plans greatly depend on the State adopting WTE as a solution to disposal of post-recycled MSW. In addition, California needs to recognize that WTE technology is based on sound science, incorporates the best available technologies, and generates renewable energy [48].

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