Feasibility Study of a California, Landfill Sited, 10 MW_e, Waste to Energy Project Driven by Landfill Cutbacks and Electricity Deregulation

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This paper reports on a feasibility study of a 10 MW_e Waste-to-Energy plant (WTE), incinerating processed municipal solid waste (MSW) on a California landfill site. The study was motivated by California Assembly Bill 939 which requires each city to reduce the amount of solid waste it landfills at the end of 2000 to 50% of the amount landfilled in 1989. The act previously mandated a 25% reduction in the amount landfilled at the end of 1995. California Assembly Bill 1890 on electricity deregulation is another motivator; the power generated is marketed locally, without transmission charges. The WTE studied consumes 122,000 tons/year of Refuse Derived Fuel (RDF) processed in an on-site Material Recycling Facility (MRF). The WTE consists of (i) two 70 Million Btu/h, two-stage Heuristic EnvirOcyclers, (ii) two Heat Recovery Steam Generators (HRSG) and (iii) a condensing steam turbine driving a 10 MW_e electrical generator. Gross power produced is 9.6 MW_e. No process heat is recovered. The power is sold for 4¢/kW.h. Based on a $22/ton RDF tipping fee and a 10 year MRF/WTE operating life, the return on investment is estimated to be 25%.

1. INTRODUCTION

Two California Assembly Bills - AB 939 (1989) and AB 1890 (1996) - serve as the impetus for the present project. AB 939, the California Integrated Waste Management Act, requires each city to reduce the amount of solid waste it landfills at the end of 2000 to 50% of the amount it landfilled in 1989. This same act previously mandated a 25% reduction in the amount landfilled at the end of 1995. AB 1890, the California Public Utilities Restructuring Act, completely altered the way electricity is generated, transmitted, distributed and billed in California.

This paper describes a 10 MW_e, MRF/WTE system in California, fueled by combustible MSW that can no longer be landfilled. The economics of this system are enhanced because the power generated can now be sold locally without a transmission charge.

The MSW is processed in a MRF. The material that can be composted is composted. The material that can be recycled is recycled. The non-recyclable, non-combustible material is landfilled. The non-recyclable combustible material becomes RDF.

357 tons/day of RDF - comprised mainly of wet, sandy/gritty, paper-like material - are disposed in a WTE located on the MRF site. The WTE consists of a 3 day RDF storage bin, two Heuristic two-stage 70 Million Btu/h EnvirOcyclers, two 50,000 lb/h, 600 psig/680^{o}F HRSG's and a single 10 MW_e condensing (2.5" Hg) steam turbine generator. A gross 9.6 MW_e is generated. Figure 1 is a schematic of the WTE. Figure 2 shows a Heuristic EnvirOcycler.

2. NOVEL FEATURES OF THIS MRF/WTE SYSTEM

2.1. Heuristic EnvirOcyclers used to Dispose of RDF

The clean burning EnvirOcycler is a proven two-stage combustor with an 18 year continuous track record in the North American forest products industry by two of its precursors at Northwood Panelboard in Solway, MN. The precursor, developed in 1976 by one of the authors, successfully burned RDF in 1978. The RDF was produced by the US Bureau of Mines' plant in College Park, MD. This test was conducted on a burner which normally direct-fired two lumber dry kilns with 2,000^{o}F products of combustion of wood waste in a sawmill in Vanderhoof, BC, Canada.

The EnvirOcycler gasifies wet RDF in a very large first stage of gentle updraft gasification. First stage producer gas is completely burned in a refractory-lined, second stage of vigorous cyclonic combustion. The second stage is located immediately above the first stage. A 3 day, 600 unit (a unit is 200 ft^3), RDF storage bin ensures a continuous flow of RDF to the 2, one hour (4 units) metering bins which feed each EnvirOcycler, 24 hours/day, 7 days/week.

2.2. "Clean" Power Generated at the MRF Site

The products of combustion from the two EnvirOcyclers are routed to two HRSGs. High pressure steam from both boilers drives the condensing steam turbine generator. The two EnvirOcyclers, the two boilers and the turbine/generator are housed in a common building on the MRF site.

Staged combustion results in low NO_x levels. Double vortex combustion in the refractory-lined second stage results in low CO levels. The combination destroys the great bulk of any dioxins or furans that might be produced in the EnvirOcycler's first stage; no furnace waterwalls are present to draw heat out of the reacting products of combustion.

However, even though the EnvirOcycler easily meets the EPA's particulate limit for incinerators of 0.08 gr/dscf (grains per dry standard cubic foot) at 12% CO_2 by volume, each HRSG is fitted with the appropriate stack cleanup devices needed to ensure boiler discharge compliance with California air standards.

2.3. Power Sold to Local Electricity Consumers Without Transmission Charges

Local sale of power produced is possible because AB 1890 dismantled the existing electrical monopolies in California on January, 1st 1998. In their place AB 1890 completely restructured the generation, the transmission, the local distribution, and the metering/billing of electricity in California. Power can now be sold locally, unburdened by a transmission charge. As a result, it is projected that in the year 2000, when the average energy rate is assumed to be 3¢/kW.h and the average transmission charge at least 1¢/kW.h, Such a system will be able to charge a full 4¢/kW.h for power sold locally.

3. CALIFORNIA LANDFILL RESTRICTIONS

AB 939 placed the onus of landfill diversion compliance squarely on the cities. Each city had to establish its Source Reduction and Recycling Element (SRRE). The SRRE was required to quantify and characterize the waste produced and diverted in 1990. As a result the allowable tonnages each

city could landfill after the end of 1995 and 2000 were established.

Table I
Summary of Solid Waste Generated by the City of Irvine in 1990
Tons/year

Sources	Total Waste Generated	Combustibles Landfilled	Combustibles Available for WTE
Single Family	39,240	26,477	24,477
Multi-family	6,728	4,624	4,624
Residential	45,968	31,101	31,101
Commercial	119,748	80,954	9,965[(a)]
Industrial	47,357	32,334	not permitted[(b)]
Allocated Industrial	197,591	Na	Na
Totals	410,664	144,389	41,066

(a): All the Commercial waste available to WTE because of the CIWMB's 10% incineration limit
(b): No Industrial waste available to WTE because of the CIWMB's 10% incineration limit

In addition to establishing the amount of waste to be diverted from California landfills, AB 939 also created the California Integrated Waste Management Board (CIWMB). The CIWMB has since ruled that the amount of solid waste that can be incinerated is limited to 10% of the total waste collected. Total waste includes all compostable, recyclable and inert materials collected.

3.1 The City of Irvine

The City of Irvine used the results of a 1990 Orange County waste generation study to prepare its SRRE. The results of this city's waste study are shown in Table I below. Column 2 of Table I lists the tonnages of the various wastes - Residential, Commercial, Industrial and Allocated Industrial - generated by the City of Irvine in 1990. "Allocated Industrial" waste includes concrete, mixtures of concrete and asphalt, construction and demolition debris, etc., and is considered to be inert. Column 3 of Table I lists the combustible portion of the total waste that was landfilled in 1990; the 144,389 ton total is made up of paper, plastics, yard waste, organic waste, and diapers.

Column 4 of Table I lists the combustible waste that could have been disposed in a hypothetical Irvine WTE at that time. Because of the CIWMB's 10% incineration limit, only 41,066 tons of waste (10% of the total 410,664 tons) would have been available for incineration. Column 4 shows that the waste incinerated would have consisted of all Irvine's combustible Residential waste, about 12% of its combustible Commercial waste and none of its combustible Industrial waste.

It can be shown that, at the current California tipping fee of $22/ton, and at an electricity rate of 4¢/kW.h, the economics of this MRF/WTE system are such that the smallest practical system is one which disposes of 122,000 tons/year of RDF. Therefore, because of the CIWMB's 10% incineration limit, combustible waste from three Irvine-size cities would have been needed to supply 122,000 tons/year of RDF to this hypothetical WTE in 1990- in spite of the fact that over 144,000 tons/year of Irvine combustible waste was available.

3.2. City of 365,000 Population

The City of Irvine has a population of about 135,000 people. In the year 2000 the City of Irvine is expected to produce about 10% more waste than it did in 1990. Accordingly, the amount of

Table II
Summary of Solid Waste Generated by a City of 365,000 population in 2000
Tons/year

Sources	Total Waste Generated	Combustibles Landfilled	Combustibles Available for WTE
Single Family	116,574	78,658	78,658
Multi-family	19,988	13,737	13,737
Residential	136,562	92,395	92,395
Commercial	355,747	240,498	29,605[(c)]
Industrial	140,688	96,058	not permitted[(d)]
Allocated Industrial	587,003	na	Na
Totals	1,220,000	428,951	122,000

(c): All the Commercial waste available to WTE because of the CIWMB's 10% incineration limit
(d): No Industrial waste available to WTE because of the CIWMB's 10% incineration limit

combustible waste which can be disposed by incineration today increases from 41,066 to 45,173 tons/year. What size city is needed today to produce 122,000 such tons/year?

Scaling 45,173 tons/year up to the 122,000 tons/year requires combustible waste from a city of 135,000 * (122,000/45,173) 365,000 people. Table II, a revised Table I, shows the waste figures for a city this size. Table II establishes the basis for the subject 10 MW_e, MRF/WTE System.

4. RDF PREPARATION

The following processes and equipment are needed for the MRF:

1. A large tipping floor on which the waste is dumped and from which the white goods, hazardous chemicals, mattresses, etc., are removed by hand
2. A pit into which the waste is shoved by a front end loader and from which the waste is then "metered out" by a "Bobcat", or picked out by a cherry picker, onto a belt conveyor passing through the MRF.
3. One or more magnetic separators to remove ferrous material
4. One or more eddy current separators to remove the aluminum
5. One or more shredders to shred the residual waste to 3" minus
6. One or more trammel screens to removal the fine dirt, broken glass, etc
7. Belt conveyors to bring the RDF to a three day storage bin
8. A 600 unit RDF storage bin
9. A separate system to take yard waste and dump it onto the conveyor feeding the shredder

For the purposes of this study it is assumed that the income from recycling will offset the MRF operational expenses. No net revenue from the MRF is include in the financial projections.

5. ECONOMIC EVALUATION

5.1. System Cost

The installed cost of the MRF is estimated to be $3 Million. The installed cost of the WTE is estimated to be $12.1 Million. The total project cost is estimated to be $15.1 Million

5.2 Economic Evaluation

Assuming power sales at 4¢/kW.h and a tipping fee of $22/ton, the annual income from electricity sales and from tipping fees is estimated to be $5.526 Million. Annual expenses such as operating personnel, management, maintenance, equipment & supplies and ash removal are estimated to be $1.578 Million. The gross project profit is $3.948 Million for the first year. Assuming an overall yearly escalation of 2 percent , the accumulated ten year gross profit is $43.26 Million. The average annual internal rate of return for a ten year operation is 25 percent per year.

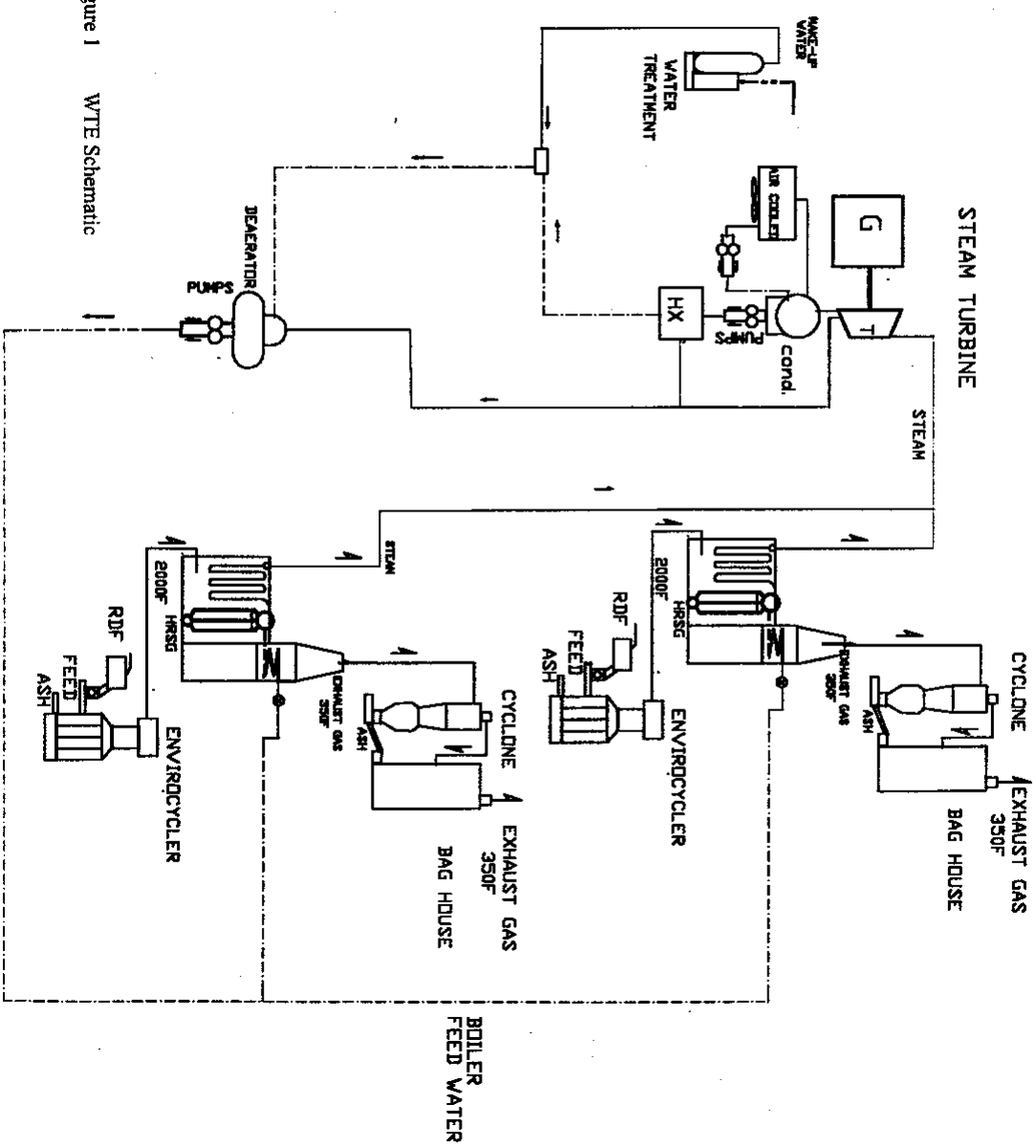

Figure 1 WTE Schematic

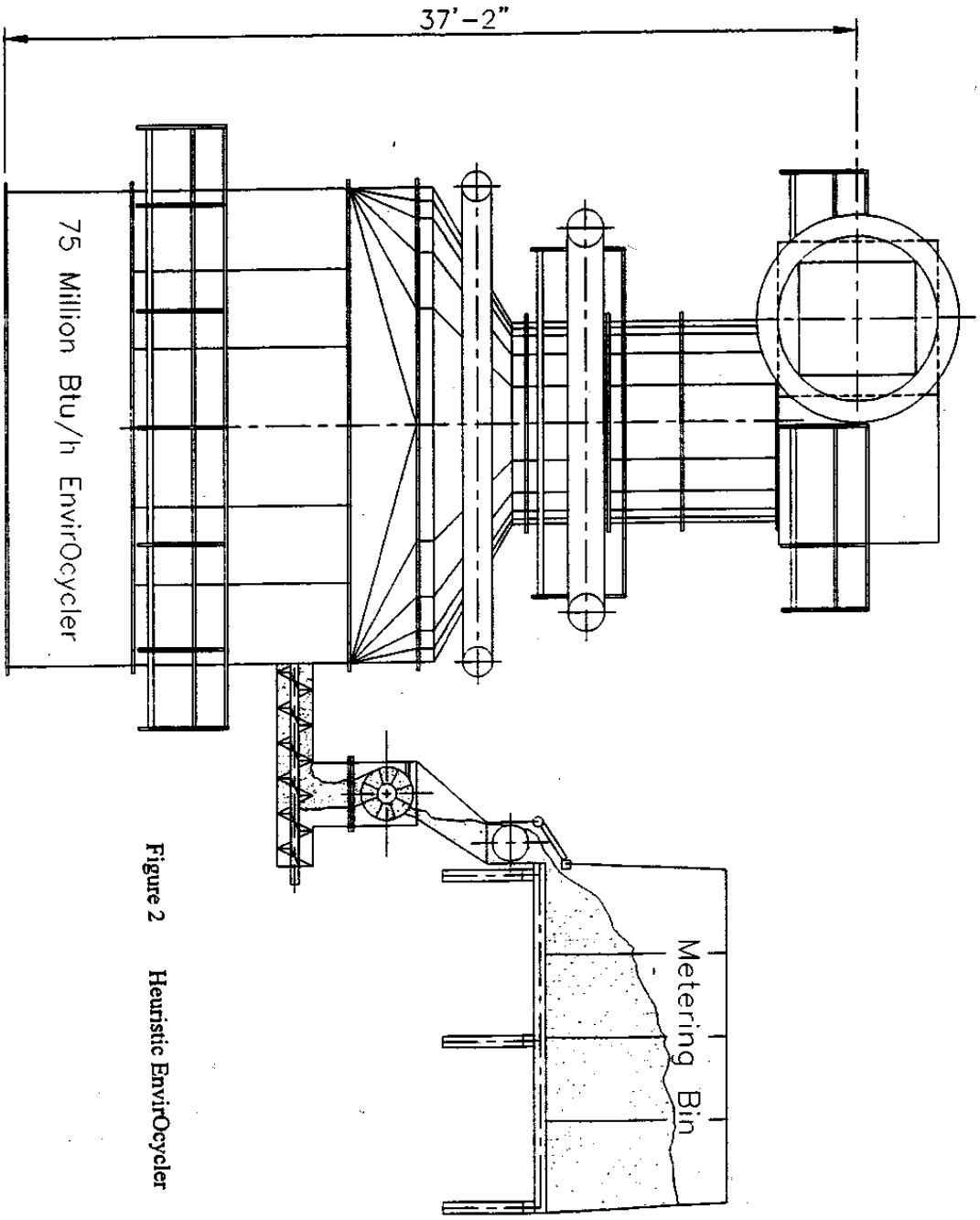

Figure 2 Heuristic EnvirOcycler