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DOE/SF/11958-T1
(DE84008564)

MUNICIPAL SOLID WASTE ENERGY CONVERSION STUDY ON
GUAM AND AMERICAN SAMOA

March 31, 1984

Work Performed Under Contract No. AC03-83SF11958

Barrett, Harris & Associates, Inc.
Menlo Park, California

Technical Information Center
Office of Scientific and Technical Information
United States Department of Energy

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GUAM AND AMERICAN SAMOA

U.S. DEPARTMENT OF ENERGY
CONTRACT NO. DE-AC03-83SF11958

MARCH 31, 1984

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ABSTRACT

In the Pacific Islands of Guam and Tutuila in American Samoa, conversion of municipal solid waste to useable energy forms---principally electricity but possibly steam---may hold promise for reducing economic dependence on imported petroleum. A secondary benefit may be derived from reduction of solid waste landfill requirements. At the preliminary planning stage, waste-to-energy facilities producing electricity appear technically and environmentally feasible. Economically, the projects appear marginal but could be viable under specific conditions related to capital costs, revenue from garbage collection and revenue from the sale of the energy generated. Grant funding for the projects would considerably enhance the economic viability of the proposed facilities. The projects appear sufficiently viable to proceed to the detailed planning stage. Such projects are not viable for the islands now emerging from the U.S. Trust Territory of the Pacific Islands.

CHAPTER I
INTRODUCTION

Purpose of Study

Guam, American Samoa, and other islands throughout the Western Pacific import nearly all of their energy petroleum and other supplies. The cost and uncertain availability of these supplies severely limit the economic vitality and independence of these islands. This dependence has also contributed to the significant financial burden borne by the United States Government in nurturing the island's economies.

Energy recovery is an attractive concept in such a setting. One type of energy recovery that has been gaining popularity throughout the United States is combustion of municipal solid waste (MSW) to obtain steam or to generate electricity. Development of such a facility, if feasible, would lessen the islands' dependence on imported petroleum and at the same time use a resource that otherwise would be discarded.

To evaluate the feasibility of a MSW waste-to-energy facility in the Western Pacific Islands, the United States Department of Energy (DOE) retained the firm of Barrett, Harris & Associates, Inc. in association with Gibbs & Hill, Inc. The proposed study included the following project objectives:

- o Evaluate the feasibility of energy recovery by combustion of MSW in Guam and American Samoa;
- o Develop technical and economic data needed for a "go/no-go" decision on the next step for developing such projects in Guam and American Samoa and;
- o Draw inferences on the apparent viability of such projects for other locations in the Pacific Islands.

Statement of Work

The basic engineering services identified for the MSW waste-to-energy study included:

1. Assess the quantity and energy content of MSW as being collected on Guam and American Samoa;
2. Assess the energy content of this waste as could be recovered by a suitable combustor-boiler to extract thermal energy for steam and/or electric power;
3. Estimate the capital cost of a suitable plant to perform the combustion and energy extraction and sale of energy in the form of either steam or electric power;
4. Project revenues from the sale of steam or electric power;
5. Based on the above, evaluate the economic and technical viability of a commercial MSW plant designed to combust available MSW and sell a product (steam or electric power) in such a manner as to qualify the plant for private and government financing;
6. Based on the analyses conducted for Guam and American Samoa, provide preliminary conclusions and recommendations as to the feasibility of MSW waste-to-energy facilities for other Pacific Islands; and
7. Address contingent liability and risk mitigation in financing strategy and discuss cash-flow scenarios for assumed project termination at various stages.

Organization of the Report

This report has been organized into ten chapters and two appendices. The purpose of the study and an outline of the engineering services performed during the study have been presented in this chapter. The Executive Summary may be found in Chapter II. The geographic settings of each of the islands as well as climate, population, and institutional considerations are described in Chapter III. In Chapter IV, municipal solid waste is characterized and quantified. Chapter V discusses the technology available for waste-to-energy facilities. In Chapter VI the technology appropriate for these island settings including conceptual descriptions of the waste-to-energy plants for Guam and American Samoa are presented. Estimates for capital costs, plant operations and maintenance are presented in Chapter VII and the economic and financial analysis follows in Chapter VIII. From these chapters, the viability of waste-to-energy conversion of municipal solid waste can be assessed for Guam, American Samoa and the Pacific Islands in general, and these assessments are presented in Chapter IX. Finally, the implementation strategies for these programs are presented in Chapter X.

The appendices to the study report include a bibliography in Appendix A and the results of the computerized economic analysis in Appendix B.

CHAPTER II
EXECUTIVE SUMMARY

The economics of the Pacific Island governments including Guam, American Samoa, and the other island groups comprising the U.S. Trust Territory of the Pacific Islands, are vulnerably dependent on the importation of petroleum and other energy supplies. The combustion of municipal solid waste (MSW) may afford a dual opportunity to: 1) lessen dependence on imported petroleum; and 2) to make use of recoverable energy from an otherwise discarded resource. This study was undertaken to investigate the technical, environmental and economic viability of waste-to-energy facilities in these islands under a contract with the Department of Energy. Barrett, Harris & Associates, Inc. in association with Gibbs & Hill, Inc. were the investigators.

The study involved: 1) assessing appropriate technology; 2) estimating costs for capital investment, operations and maintenance; and 3) conducting economic sensitivity analyses with respect to costs, methods of financing, and revenue from the sale of energy.

The study indicates that waste-to-energy facilities would be technically and environmentally viable but, under the assumed conditions, only marginally economical on Guam and on Tutuila Island in American Samoa. The remaining islands do not generate sufficient MSW to make waste-to-energy facilities viable in the near future.

For Guam, lower capital costs through the use of competitive procurement methods, reduced operating expenses, increased revenues from garbage collection fees and a higher revenue from the sale of electricity would make the facility economically viable.

For Tutuila Island in American Samoa, grant funding is the single most overriding economic factor without which the proposed

facility is probably not economically viable given the assumed conditions. Economic viability can be enhanced by lower capital and operating costs, increased revenue, from garbage collection fees, and a higher revenue from the sale of electricity.

The next step in development of these projects is to explore the various means available for enhancing the economic viability of the projects. These activities should include:

- o Investigation in greater detail of the proposed facilities to achieve construction cost reductions including: 1) sources of less expensive labor, materials and equipment; 2) use of turnkey construction method; and 3) possible integration of the combustor-steam process of the waste-to-energy facility with an existing steam electrical generating facility (valid only for Guam's case).
- o Investigation of the feasibility of increasing revenue through institution of a municipal solid waste collection fee.
- o Exploratory discussions with electric utility agencies for establishing and obtaining a commitment to purchase electricity produced by the waste-to-energy facility.
- o Initiation of more extensive data collection to better establish the quantities and compositional nature of the MSW generated on Guam and Tutuila Island in American Samoa.

FIGURE 3-1
GEOGRAPHIC LOCATION MAP
GUAM AND AMERICAN SAMOA

CHAPTER III

DESCRIPTIONS AND CHARACTERISTICS OF THE STUDY AREAS

General

This chapter provides background data regarding the geographic setting, climate, and population of Guam and American Samoa. In addition, various institutional considerations relative to collection and disposal of municipal solid waste (MSW) and the potential for recovery of materials as well as conversion of waste to energy are discussed. These factors are important to understanding and appreciating the economics of resource recovery and waste-to-energy conversion in these islands.

Much of the information in this chapter has been derived and excerpted from previous studies, particularly the Territorial Energy Assessment Final Report prepared in 1982 by the Department of Energy. Readers are referred to this study as well as others listed in the bibliography (see Appendix A) for more detailed and comprehensive discussions of the information summarized in this chapter.

Geographic Setting

As shown on Figure 3-1, Guam and American Samoa are located approximately equidistant north and south respectively of the equator in the Western Pacific. Guam is located at an approximate latitude of 13°38' North and longitude of 144°45' East; American Samoa at an approximate latitude of 14°30' South and longitude 170°50' West. Geographically, Guam belongs to the group of islands known as Micronesia whereas American Samoa is part of Polynesia. The immediate geographic and topographic settings of each island are further described in the following paragraphs.

Guam is the westernmost territory of the United States and is the southernmost island in the Marianas Archipelago. There are fifteen islands in this archipelago that form an arch approximately 500

miles long, separating the Pacific Ocean and the Philippine Sea, as shown on Figure 3-2. The four major populated islands in the chains are Saipan, Tinian, Rota and Guam, with Guam being the largest, having an area of approximately 212 square miles. The Island is approximately 30 miles in length with a width of 8-1/2 miles at the northern tip and a maximum width in the south of 11-1/2 miles. The northern and southern land areas taper at the Island's center to a width of 4 miles.

Guam was formed through an uplift of undersea volcanoes and is surrounded by coral reefs near the shore. The northern part, which contains the main fresh water lens, is a high coralline limestone plateau rising up to 850 feet above sea level. The southern part is mountainous, of volcanic origin, with peaks to 1300 feet. Apra Harbor, one of the largest protected harbors on earth, is located on the western side of the Island.

The Territory of American Samoa, the only United States territory south of the equator, includes the seven eastern islands of the Samoan Islands, as shown on Figure 3-3. Tutuila, the main island, has 53 square miles of land area, and Aunu'u, 1.0 miles off the southeast coast of Tutuila, has 0.5 square miles of land area. The Manu'a group is 69 miles to the east. Rose Island, 240 miles east of Tutuila, is only 0.2 square miles in area. Swain's Island, 270 miles to the north, is 1 mile square. All of the islands are inhabited except for Rose Island, which is a wildlife preserve.

Tutuila's topography is rugged. The island is a continuous, narrow irregular volcanic ridge rising steeply from the ocean. The Tufuna Plains on the southwestern portion of the Island are the only expanse of relatively flat land. The ridge forms a drainage divide for the entire island. Numerous short, intermittent streams descend from the mountains through steep valleys. Larger streams have formed wide, flat, delta-shaped valley floors where they emerge from the highlands to enter the sea. Many of the villages are located near the stream mouths.

• Forallon de Pajeros

•• Maug Islands

• Asuncion

• Agrihan

• Pagan

MARIANA

• Alamagan

• Guguan

ISLANDS

• Sarigan

Anatahan

• Forallon de Medinilla

• Saipan
• Tinian
• Aguijan

Rota

Guam

SOURCE: U.S. DEPT. OF THE INTERIOR

0 50 100
MILES APPROX.

**FIGURE 3-2
VICINITY MAP OF GUAM**

Pacific Ocean
Swain's Island

AMERICAN SAMOA

FIGURE 3-3

VICINITY MAP OF
AMERICAN SAMOA

Tutuila is about 20 miles long, 6 miles wide at its widest extent, and less than 1 mile wide where Pago Pago Harbor intersects the ridge near the center of the Island. The ridge rises abruptly from the sea, and numerous peaks range in elevation from 1000 to 1500 feet. Mt. Matafao at 2141 feet, is the highest peak.

On Tutuila, the steep slopes, heavy rainfall, and rapid runoff keep the natural residual soil cover thin. The soil on the steep slopes is held in place only by a dense growth of tropical vegetation. Overlying the narrow belt of coral around the edge of the Island is a thin cover of sandy, organic material that also supports abundant vegetation. In a few inland valleys, thick deposits of alluvial soil may be found.

The Manu'a group consists of three separate islands: Ofu, Olōsega, and Ta'u. Ofu and Olosega are remnants of a single volcanic island and are separated by a 500-foot wide strait. Both islands rise abruptly from the ocean with little flat land other than a narrow band along the coast. There are few well developed drainage basins on either island. The combined land area of Ofu and Olosega is approximately 4.9 square miles.

Ta'u is the largest of the Manu'a islands, covering 17.7 square miles. The south side of the Island consists of spectacular cliffs and cascades dropping directly into the sea. Most of the coastline along the northern and western sides of the island is fringed by a fairly wide coastal plain fronted by narrow beaches. The villages on the west end of the island are built on terraces several feet above sea level which are composed of sand dunes and storm benches of coral sediments.

Climate

The climate on both Guam and American Samoa is typical of most tropical islands in the Western Pacific, i.e., characterized by warm, humid weather throughout the year. Very little variation exists in monthly mean temperatures.

On Guam, mean annual temperature near sea level is about 81°F with the monthly mean ranging from 80°F in January to a little over 82°F in June. Rarely does the temperature exceed 90°F during the daytime hours or fall below 70°F at night. The relative humidity commonly exceeds 84 percent at night, year-round, with the average monthly humidity being at least 66 percent.

Guam's climate is characterized by two distinct seasons: a dry season from January to May and a wet season from July to November, with June and December being transitional months.

The mean annual rainfall varies from about 80 inches on the central and coastal lowlands to about 110 inches on the uplands in southern Guam. A wide variation in rainfall can occur from year to year. In 1952, a maximum of 145.45 inches was recorded while the minimum rainfall recorded was 60.42 inches in 1955. Severe droughts are common between February and April.

The easterly trade winds with velocities between 4 and 12 miles per hour (mph) are dominant throughout the year on Guam. Only occasionally do winds exceed 24 mph except during major tropical storms or typhoons. Small storms or squalls can occur at any time with little notice. The likelihood of typhoons is greatest during the period between July and September, but they can occur during any month of the year. In May of 1976, Typhoon Pamela caused extensive destruction on the Island with recorded sustained winds of 215 mph and recorded gusts to 259 mph.

On American Samoa, monthly temperature means range from 80°F in July to 82°F in February, the hottest month. Mid day temperatures of 85°F are common.

Rainfall on American Samoa averages nearly 200 inches per year, about twice Guam's annual mean rainfall. However, there is great variation in rainfall. In 1906, for example, rainfall was only 130 inches; three years later, rainfall measured 284 inches. February

is usually the wettest and hottest month, while June, July and August are relatively dry.

Relative humidity is also consistently high in American Samoa, ranging from 70 to 90 percent during the wet season and from 60 to 70 percent during the dry season. The high humidity in both islands encourages decomposition of municipal solid waste.

Population

The civilian population of Guam is concentrated in the central part of the island. As is the case in much of the world, considerable population redistribution has taken place since the end of World War II, predominantly from rural to urban areas. In Guam, this means from the south to the central portion of the island. Guam's population density is approximately 490 people per square mile of land area, about eight times the United States average of 62 per square mile. Guam has a higher population density than all of the states except Massachusetts, Rhode Island, Connecticut and New Jersey.

The present population of Guam, based on 1980 census figures, is 105,800, of which 21,500 are military personnel and their dependents. About 48 percent of the population is ethnic Chamorro, 24 percent is Caucasian (mostly from the United States), 20 percent is Filipino, 3 percent is Korean, 2.7 percent is Micronesian, and the balance consist of Japanese, Chinese and other ethnic groups.

Between 1920 and 1940, Caucasians and Filipinos accounted for only 4 percent and 3 percent, respectively. The growth in the Caucasian fraction is mainly due to increased military strength on the island while the increase in Filipinos comes largely from immigration.

According to estimates by the Bureau of Planning of the Government of Guam, the population on Guam will double by the year 2000 if the present rate of growth is maintained. Much of the increase in population is expected to occur in the civilian and tourist sectors. Significant changes in military personnel levels are not

anticipated by the Department of the Navy for the foreseeable future.

American Samoa's resident population in 1981 was 33,160. Ninety-three percent (30,212) of the people live on Tutuila, mostly in rural communities. Less than 3,000 people live on the Manu'a group and the atolls. Pago Pago Bay on Tutuila is the economic center of American Samoa, however, a new industrial center is being developed in the Tufuna area. There is a significant amount of emigration out from American Samoa, mostly to Hawaii and the United States mainland. There are between 80,000 to 100,000 American Samoans living in the United States now, including those serving in the armed forces.

Since 1980, the population of American Samoa has been increasing by about 7 percent per year. The territory is expected to continue experiencing a steady increase in population during the next decade, primarily in the Tufuna Plains and West Tutuila areas where the greatest amount of flat land is available. Populations of the Pago Pago Bay and northeast and southeast island areas will increase only slightly because land for residential, commercial, and industrial purposes is scarce. Population of the Manu'a group will probably increase slightly because of expected improvements in inter-island travel and minor improvements in job opportunities.

A summary of the 1980 population for Guam, American Samoa and other Pacific Island locations is shown in Table 3-1.

Political and Economic Settings

Key economic and technical variables, related to the financing, marketing and costs of waste-to-energy facilities, have been identified for assessing the viability of these facilities on Guam and American Samoa. These variables are presented and discussed in greater detail in subsequent chapters of this report. To enable better understanding and appreciation of these variables, the history, political development, and general economic environments of Guam and American Samoa are briefly presented in this section.

TABLE 3-1
ISLAND POPULATIONS

<u>Island Group</u>	<u>Population</u>
Guam	105,000
American Samoa	32,400
Northern Marianas	16,900
Marshall Islands	31,000
Palau	12,000
Federated States of Micronesia Total	74,700
Truk	38,000
Ponape	23,000
Yap	8,200
Kosrae	5,500

Guam - In 1950, President Truman signed the Organic Act of Guam, giving the Island the status of an unincorporated territory, extending American citizenship to its people, and providing local legislative autonomy. The Act also transferred administration of Guam's civil affairs to the United States Department of the Interior and placed the executive, legislative, and judicial branches of local government in civilian hands. The Organic Act was subsequently amended several time and is now the Island's basic constitutional instrument.

Since 1970, the executive branch has been headed by an elected Governor and Lieutenant Governor. Guam's 21-member unicameral legislature is elected every two years and has full power in territorial matters, including limited taxation and appropriation authority.

Guamanians enjoy most of the privileges of American citizenship, but they cannot vote in United States presidential elections unless resident in one of the states. They have an elected representative in Washington, who serves for a two-year term and who exercises the

rights and privileges of a United States Congressman except for the right to vote on the floor. They have most recently indicated in a 1982 political status referendum the desire to move toward a commonwealth status.

Government constitutes the largest economic sector on Guam, with federal and local government expenditures playing a dominant role in sustaining the economy. The Department of Defense (DOD) has 5,623 civilian employees. All public employees account for about one-half of the work force (about 17,000 out of the total of 34,000).

Guam's job market has shown substantial improvement during the recent past. Increased tourism is providing many new jobs with estimates for 1981 being 4,000 direct jobs and 1,600 indirect jobs in this industry. Manufacturing accounts for about 1,200 workers. According to the latest available figures, the jobless rate declined from 7.6 percent in September 1978 to 7 percent in September 1979. According to the same figures, Guam's total personal income for 1978 was \$366 million, an increase of 24 percent from the \$295 million in 1977. The annual per capita income gained 20 percent during the same period, from \$3,511 to \$4,198. A survey of households showed the 1978 average income of approximately 19,000 households to be \$19,309. This survey excluded active duty military personnel, their dependents living on military bases and non immigrant aliens.

The economic impact of the federal government, primarily by the military, can be measured by its total expenditures of \$671 million in 1981, consisting of military and civilian pay, military construction, and federal income taxes which are reverted to the government; the number of civilians employed by the DOD, 5,623; and the land area under its ownership, some 40,000 acres (16,000 ha). Military exchanges and commissaries account for about 20 percent of all local retail sales.

A multitude of federal agencies are also involved, in cooperation with the local government, in improving the existing infrastructure. Projects involving transportation, port, telephone, power, water and sewer facilities are in various stages of completion. Notable among current and future capital improvements projects are the new air terminal complex, the commercial port expansion, public utilities improvement and expansion, renovation of University of Guam and public school facilities, and expansion and establishment of an agricultural and industrial park. Improvements to these public facilities are crucial to future economic development.

Although Guam has enjoyed considerable economic growth over the past decade, and the essential elements are present for continued expansion, Guam's present economic base is limited, thus, substantial assistance from the United States government will continue to be needed to sustain economic growth. Because government and tourism are the largest sectors, the economy will remain vulnerable to outside influences such as changes in military deployments and economic conditions elsewhere.

Fortunately for its economy, Guam is strategically located to assume a role of growing importance in United States affairs in the Western Pacific region. Given this fact, and the declining United States military presence in the Far East, the military establishment can be expected to remain on the Island in force. The future for the tourist industry also looks bright, provided the supporting infrastructure can keep pace with the expansion. Included in this expansion will be all utilities, the number of hotel rooms, and development of beaches, parks, and other tourist-oriented facilities.

These prospects for continued economic growth notwithstanding, an enlarged and diversified manufacturing base is needed to balance the present emphasis on tourism. The Government of Guam recognizes this need and its present policies call for encouraging the establishment of new industries in light manufacturing and for

initiating an incentive program to accelerate expansion of existing manufacturing firms. The Guam Economic Development Authority (GEDA) was formed in 1965 to encourage and participate in the growth of this sector.

Guam's energy situation is significantly affected by two large military facilities on the Island (Commander Naval Forces, Marianas, and Andersen Air Force Base, 43rd Strategic Wing). The military's fuel requirements and the energy used by 21,500 military personnel and dependents on the Island affect the domestic market. The military accounts directly for almost half of the electrical energy use and consumes 55 percent of the petroleum.

Electrical power generation represents the largest single civilian use of conventional fuels on Guam. The Island's power generating facilities include the Piti Power Plant, the Tamuning Power Plant, smaller plants in Dededo and Tamuning, back up generators, and the power barge, Inductance, which is owned by the Navy. Peak demand for electricity has not changed significantly in six years. Thus Guam's generating capacity will probably not need expansion in the near future.

The Navy and the Guam Power Authority (GPA) generate electrical power for the entire Island under a power pooling agreement. The Navy operates the load dispatching center of the Island-Wide Power System pool and shares power generating costs with the GPA. The GPA buys fuel for all the plants within the pool. The Navy currently supplies 12 percent to 20 percent but consumes 40 percent of the total power generated. In an effort to assist in the payment of GPA's debt obligation, the original power pool agreement has been amended to require the Navy's current contribution.

American Samoa - The Deeds of Cession granted American Samoans United States national status, protected them under the United States Constitution, and prevented their lands from being alienated. The day-to-day government was derived from United States Naval regulations, which today form the basis of the Code of

American Samoa. The Fono, a bicameral legislation, was formally organized in 1949 and became the Territory's law-making body. In 1951 an executive order transferred administration of American Samoa from the Navy to the Department of the Interior. In 1960, the American Samoans held a constitutional convention, and the resulting constitution became effective later that year. In 1977, Samoa elected its first governor and lieutenant governor, a step which nearly completed the process of local self-government. The government now consists of three branches: executive, legislative, and judicial. Samoa also elects a congressional delegate, who became a non voting member of the United States Congress in 1981.

The current relationship of American Samoa and the United States is spelled out in Secretary Order 2657 of the Department of the Interior. With the installation on January 3, 1989, of the first popularly elected government in Samoan history, the American Samoans initiated an aggressive development program. This program called for economic and infrastructure development to bring the territory closer to self-sufficiency, greater economic and social participation in the community of emerging South Pacific nations, and greater self-government and political development within the United States community.

The wage economy for American Samoa centers around the Pago Pago Bay area. The principal industry is tuna processing. The two canneries located in the Pago Pago Bay area employ about 20 percent of the work force. Subsistence family agriculture and small, family -owned businesses are also found throughout Tutuila and on the outer islands. The labor force for 1980 was 10,596, about 31 percent of the population. The unemployment rate for 1980 was about 12 percent.

American Samoa differs from Guam and most of the other United States Pacific Islands in that it has a substantial export industry: tuna processing from two large canneries, Van Camp and Star Kist. Sources of tuna are the 125-boat, long-line fishing

fleet owned largely by Koreans and Taiwanese, and about ten United States-owned purse seiners, docked within Pago Pago Bay.

The boats are individually owned, but both fleets have contracts with the canneries. Like the canneries, the fishing fleets are encountering hard times caused by increasing expenses and long layovers. In 1977, tuna exports were \$73 million; in 1978, \$96 million; and in 1980, \$125 million. However, 1982 was a bad year for the industry; sales dropped considerably, and one of the canneries closed for a month.

Historically, Pago Pago has also been an important fueling station for South Pacific sea traffic because of its deep water port. It continues that role today with expanding port and servicing facilities, and diesel exports are high. The Marine Railway facility near the canneries does ship repairs and maintenance.

Tourism is a slowly growing industry. There is only one hotel on Tutuila, and there is a general reluctance to change traditional ways to accommodate visitors. This industry is vulnerable to changes and cutbacks in air schedules, as occurred in 1982 when two major international airlines stopped flying to American Samoa.

The first priority of the American Samoan Government (ASG) is economic development. However, the ASG does not want to develop with absentee ownership, i.e., only Samoans can own Samoan land. Therefore, economic development will probably occur at a deliberate pace.

American Samoa has a relatively well-developed public and institutional infrastructure including water and wastewater systems, paved roads in almost every village, an international airport, and one of the best deep water harbors in the world, Pago Pago Harbor. Port facilities in Pago Pago Harbor are just now being enlarged.

With respect to electrical power generation, a total capacity of 30 MW presently exists on Tutuila. The available reserve margin fluctuates between 0 and 2 MW. Minimum daily demand is a 8 MW and average daily peak load is 13 MW.

There are two diesel-generator power plants on Tutuila, one at Satala near the canneries on Pago Pago Bay (16 MW), and the other at Tufuna near the airport (14 MW). They are about 12 miles apart and are connected by a tie-line for transmission of power from either one. Satala is the older of the two stations; its first generator system was installed in 1962. There is on-site storage for 48,000 gallons of diesel fuel. The system serves mostly the canneries and the industrial part of the island. The first generator was installed in the Tufuna station in 1974. This station serves the western part of the Island which includes the airport, a new industrial park, and a large residential area. There is on-site storage for 200,000 gallons of diesel fuel. The actual amount stored is generally no more than 60,000 gallons. The grid connects to every village on Tutuila, and an underwater cable connects the grid to Aunu'u Island.

These power generating stations are owned by the American Samoa Government and until recently were operated and maintained by the Electric Utility Division (EUD). In 1981, the new American Samoa Power Authority replaced the EUD. The new Power Authority has the right to make contracts, purchase and lease property, and suggest rates. Rates are set by vote of the people. Over the years maintenance programs and plant conditions have ranged from fair to good. Both plants are in fair condition, however, power outages are common, and the ASG recognizes that generating reliability and capacity must increase and the total dependence on imported fuel sources must change if American Samoa's energy program is to encourage economic development.

There are two generating systems in the Manu'a group: two diesel generators each on Ofu and Ta'u with a total installed capacity of

1 MW. All villages in the Manu'a group are connected to the grid. Swain's Island has only a small diesel generator.

The present production of electricity on Tutuila is barely adequate, despite new equipment and improved maintenance. Economic expansion will be difficult without additional capacity. The present system is inefficient, and price increases or interruptions in fuel supply will have drastic effects on the Territory's economy and well-being.

CHAPTER IV
WASTE CHARACTERIZATION AND QUANTITIES

General

Municipal solid waste (MSW) is generally defined as refuse material generated in households, business and commercial establishments, and institutions such as hospitals, schools and government offices. MSW is comprised of combustible materials, e.g., paper, plastics, food wastes, textiles, etc., and noncombustible material such as metals, glass and miscellaneous inorganics.

The source of energy in a stream of MSW is derived from the combustible portion. The amount of energy that can be recovered depends to a great extent on the characteristics of the combustible material and the available quantities. In this chapter, the characteristics and quantities of the MSW generated in Guam, American Samoa, and other Pacific Islands will be discussed.

Previous studies have assessed the solid waste management problems in Guam, American Samoa, and other Pacific Islands. These studies are listed in the bibliography provided in Appendix A. They are specifically identified as reference sources in the respective discussions of the islands.

Actual data is generally unavailable regarding the composition of MSW in Guam, American Samoa and the other Pacific Islands, despite these previous studies. Only one study to date has actually involved a survey, limited as it was, to determine the composition of the MSW on Guam. Furthermore, data collection by the various agencies of the respective island governments which are responsible for solid waste collection, is generally not accomplished. Commercial solid waste collection companies also do not maintain records of the composition of the waste they collect.

It is beyond the scope of this study to determine in detail, through physical surveys or other quantitative methods, the actual

composition of MSW in these islands. Thus the quantities and composition of MSW as presented in this chapter, should be recognized as being estimates based primarily on past studies and on-site observations conducted during site visits to Guam and American Samoa as part of this study.

Data regarding the quantities of MSW generated on Guam and American Samoa are more readily available as compared to the compositional data. The quantitative data, as collected, however, are in cubic yards of waste since this unit relates directly to the number of trips made by the collection crews. To convert the volumetric data to tonnage density values for the waste will have to be assumed. The density of MSW, in general, depends on whether the waste is compacted or not. For the purposes of this study, all compacted wastes will be estimated to have a density of 600 pounds per cubic yard (lb/cu yd) and uncompacted wastes, a density of 200 lb/cu yd.

The remainder of this chapter discusses the composition of waste generated in Guam, American Samoa and other Pacific Islands.

Guam

The Department of Public Works (DPW) Government of Guam, collects residential and commercial wastes and operates the Ordot Landfill site and two waste transfer stations, one at Dededo and the other at Malojloj. Commercial Sanitation System, a private hauler, also collects residential and commercial wastes and transfers wastes from the two transfer stations to the Ordot Landfill site.

The Ordot Landfill has been characterized as having a long history of operational and environmental problems and is approaching its holding capacity. In addition to this disposal problem, solid waste is sometimes not collected for disposal in the Ordot Landfill, and thus are disposed indiscriminately in illegal open dumps or in streams, on beaches and along roadways.

In an attempt to control the indiscriminate dumping, the Guam Environmental Protection Agency (GEPA) has attempted to establish a system of solid waste transfer stations on the Island. As mentioned, two of these stations have been constructed thus far. The solid waste transfer stations were designated to be used as a temporary storage site for household wastes before final transport to the Ordot Landfill. Ironically, the solid waste transfer stations are turning into open dumps due to operational and maintenance problems as well as additional dumping from commercial establishments and construction activity.

Municipal solid waste generated on the military bases are collected separately by the respective U.S. Navy and U.S. Air Force activity commands. This waste is disposed in landfills located at the Naval Station and Andersen Air Force Base, respectively.

As mentioned previously, data regarding waste composition are generally not available although a limited survey was conducted by Rossi Nayve Consultancy Services, Inc. in 1980. The Guam Environmental Protection Agency also prepared the "Guam Solid Waste Management Plan" in which data on the composition of MSW were reported. A more recent study entitled "Biomass Energy Options for the American Territories of the Pacific", edited by James L. Brewbaker and Kenneth G. MacDicken, also estimated percentages of the components of MSW on Guam. The various estimates from these studies are presented in Table 4-1.

TABLE 4-1

ESTIMATES OF COMPOSITIONAL PERCENTAGES BY SOURCE
FOR GUAM MUNICIPAL SOLID WASTE

<u>Component</u>	<u>GEPA</u>	<u>Brewbaker</u>	<u>Rossi Nayve</u> <u>Commercial</u>	<u>Residential</u>
Combustible	73	81	89	77
Noncombustible	27	19	11	23

Based on the estimates in Table 4-1, the composition of the MSW generated in Guam will be assumed, for the purposes of this study, to be 75 percent combustible and 25 percent noncombustible. In comparison, the average composition of MSW generated throughout the United States is approximately 79 percent combustible and 21 percent noncombustible.

With respect to the energy recoverable from the combustible components of MSW, the important parameters are moisture content and heating value. These parameters must be estimated for the purposes of this study. For Guam's MSW, the moisture content will be assumed to be 25-55 percent and the heating value is assumed to be 4,000 BTU/lb. This heating value compares well with estimates prepared in a study of MSW for the State of Hawaii by the State Department of Planning and Economic Development. The heating value of MSW on Oahu was estimated in the study at 4,400 BTU/lb.

To obtain data regarding the quantities of MSW generated on Guam, the various Government of Guam and military officials responsible for solid waste collection and disposal, were interviewed. In addition, the commercial sanitation company was also contacted. Data regarding the volumes of MSW collected by the Department of Public Works, the military and the commercial section were obtained. Table 4-2 presents the data as obtained and converted to tonnage using the appropriate density factors mentioned in the previous section of this chapter. The data in the table are for the period of January-August, 1983, representing 240 days.

The daily tonnage of MSW, estimated as shown in Table 4-2, is calculated as if MSW was collected on a seven-day basis. Actually collections are made on only five days of the week.

The estimated total of 167 TPD₇ of MSW generated by the civilian sector compares fairly well with other estimates. A feasibility study conducted in 1980 by the Guam Environmental Protection Agency, as a preliminary basis for the Solid Waste Management Plan,

indicated that approximately 140 tons per day of MSW were disposed at the Ordot Landfill. During recent interviews, the Administrator of the GEPA indicated that 150 TPD₇ is a realistic estimate of the MSW generated by the civilian sector of Guam.

For the purposes of this study, projections of future waste generation are also of significance to establish the viability of any proposed waste-to-energy facility or program. The quantities of MSW that may be generated in the future can be estimated by assuming either a two percent increase in waste generation per year or by assuming a per capita waste generation rate and applying this rate to population projections. Table 4-3 presents estimates of future daily MSW generation rates based on a two percent increase of MSW over the existing generation rate. If the population data and appropriate per capita generation rates are used, a significant difference in the estimate for future MSW generation is obtained. Assuming a population in the year 2000 of approximately 167,600, as estimated by the Guam Land Use Plan, and a combined residential and commercial MSW generation rate of 4.5 pounds per capita per day, the rate of MSW generated in the year 2000 would be as follows (military MSW generation rates assumed constant):

	<u>TPD₇</u>
Civilian	375
U.S. Navy	50
U.S. Air Force	<u>11</u>
	436

This considerable difference in the estimate of the MSW generation rate for the year 2000, may be due to errors in the projected population and/or the per capita waste generation rate. Alternatively, the rate of increase in MSW could be in error. A better estimate of MSW generation rates should be investigated perhaps during the preliminary engineering phase for a facility, should this program be pursued further. For the purposes of this study, a 250 ton per day plant capacity will be analyzed.

TABLE 4-2
QUANTITIES OF MSW GENERATED ON GUAM
 January - August, 1983

<u>Source</u>	<u>Total Volume(1)</u> <u>(cubic yards)</u>	<u>Density</u> <u>(lb/cu yd)</u>	<u>Tons per Day(2)</u> <u>(TPD₇)</u>
<u>CIVILIAN SECTOR:</u>			
Commercial Sanitation Co. (compacted)	51,211	600	64
DPW (compacted)	40,196	600	50
Private Construction	62,940	200	26
Commercial	62,549	200	26
Private	<u>2,593</u>	<u>200</u>	<u>1</u>
Sub-Total	219,489	-	167
<u>MILITARY SECTOR:</u>			
U.S. Navy	-	-	50 (3)
U.S. Air Force	-	-	<u>11</u> (4)
Sub-Total			61

NOTES:

- (1) Total volume based on collections over the indicated 240-day period.
- (2) Tons per day based on a seven day per week collection period (TPD₇) estimated by dividing total volume weight by appropriate density factor.
- (3) Estimated from interview with officials at U.S. Navy Public Works Center.
- (4) Estimated from population of 5,000 generating approximately 4.4 lbs per capita per day.

TABLE 4-3
PROJECTED MSW GENERATION RATES ON GUAM⁽¹⁾

<u>Sector</u>	Tons Per Day (TPD ⁷) by Year		
	<u>1983</u>	<u>1988</u>	<u>2000</u>
Civilian	167	234	185
U.S. Navy	50	50	50
U.S. Air Force	<u>11</u>	<u>11</u>	<u>11</u>
TOTALS	228	246	295

NOTE:

(1) Based on two percent yearly increase with 1983 estimate as a base. Military MSW generation rates assumed constant throughout period.

For the economic sensitivity analyses, variations in plant capacities will be introduced to assess impacts on revenue and costs for the facilities. A 150 TPD₇ and a 350 TPD₇ plant will be used in these sensitivity analyses, which are presented in Chapter VIII, "Economic and Financial Analyses".

American Samoa

On the main island of Tutuila, collection of MSW is the responsibility of the Department of Public Works (DPW), of the American Samoa Government (ASG). DPW maintains a collection service on eleven separate routes. MSW is collected six days a week, allowing for twice a week pick up on most areas of the Island, with the more populated areas around Pago Pago Harbor receiving collection six days a week. All collection services are provided without charge, and there are generally no restrictions on the types of waste collected by DPW.

Most of the MSW collected by DPW is disposed of in a sanitary landfill site located near Futiga Village on the southwestern side of Tutuila. The five-acre landfill site is presently being leased. On-site cinder material is used to cover the waste at the landfill but the cover provided has generally been inadequate to prevent

foraging dogs, other animals and the wind from spreading exposed refuse around the site.

According to the ASG's Solid Waste Management Plan completed in 1978, collection on the outer islands of American Samoa, which include the islands of Aunu'u, Ofu, Olesega and Ta'u is irregular and unreliable. Solid waste is either disposed of in open dumps or inadequately maintained landfills.

Solid waste is also generated by the Star Kist and Van Camp tuna processing facilities on Tutuila. However, these wastes cannot be effectively used in a municipal solid waste waste-to-energy conversion plant and are not taken into consideration in this study. It should be noted though, that the solid wastes from the canneries may be useful as a source of energy through bio-conversion (to produce methane gas) as indicated in the Department of Energy report, "Final Report on the Economic Feasibility of Producing Methane Gas from Bio-conversion of Tuna Cannery Waste," completed in September 1980.

As has been indicated previously, detailed data is unavailable regarding the composition of waste in American Samoa. Field observations conducted by DPW for the Solid Waste Management Plan indicate that 70 to 75 percent of the waste is combustible. In the absence of any waste composition data, field observations were also made during this study. Based on the field observations at the landfill site, the waste composition appears to be similar to Guam's MSW. Therefore, for the purposes of this study, the MSW on American Samoa will also be assumed to be 75 percent combustible and 25 percent inert. The moisture content and heating values will be assumed to be 25-55 percent and 4,000 BTU/lb, respectively.

During the field investigations and interviews conducted in this study, waste generation data were obtained from the Department of Public Works. Table 4-4 presents the quantities of MSW generated on Tutuila Island.

TABLE 4-4
QUANTITIES OF MSW GENERATED ON
TUTUILA ISLAND, AMERICAN SAMOA

<u>Source</u>	<u>Tons Per Week</u>	<u>Tons Per Day (1)</u> <u>(TPD₇)</u>
Government Offices, Housing,		
Hospitals and Schools	540	77
Federal Aviation Administration	15	2
Marine Railways	18	3
Miscellaneous	<u>37</u>	<u>5</u>
TOTALS	610	87

NOTE:

- (1) MSW generated in tons per day is derived from the tons per week quantity assuming a seven-day work week. MSW collection is usually less than seven days per week, and the actual amount of MSW collected in a day will probably be greater.

The quantities of MSW generated per capita on the outer islands is significantly lower than on Tutuila. The rate for the outer islands is estimated at less than 1.5 pounds per capita per day (pcd). This lower rate results from a generally lower economic level in the outer islands as well as more wide-spread practice of subsistence agriculture and fishing. These latter activities result in a lower use of packaged products and consequently less generation of municipal solid waste.

As was done in estimating Guam's future MSW generation rates, a two percent annual increase in waste production can be used to estimate the future MSW generation rates on American Samoa. Alternatively, a 4.5 pounds per capita per day generation rate, as in Guam's case, may be applied to the projections of the future population.

If a two percent annual increase in MSW production over existing

levels is assumed, future daily tonnage of MSW in the years 1988 and 2000, would be as follows:

<u>Year</u>	<u>Tons Per Day (TPD₇)</u>
1983	87
1988	96
2000	122

If the population projections and a MSW generation rate of 4.5 pounds per capita per day are assumed, the projected quantities of MSW generated on Tutuila Island by the year 2000 would be 100 TPD₇.

Those two estimates agree more closely than was the case for Guam. For the purposes of the study, the capacity of the waste-to-energy facility will be assumed to be 100 TPD₇. Further investigation should be made during the preliminary engineering phase for verifying the waste quantity. Again, the design capacity will be varied, in this case between 50 to 150 TPD₇, to assess the economic feasibility.

Because of the small resident populations in the outer islands of American Samoa there is insufficient MSW generated to justify a waste-to-energy facility except on the Tutuila Island. It should be noted, however, that large amount of biomass (e.g., coconut shell and husk) may be available from Western Samoa and the outer islands of American Samoa. If these wastes are available, the design capacity could be utilized at a much earlier date. However, moisture content, ash and the heating value of the coconut shell should be analyzed to incorporate this type of fuel in the waste-to-energy facility. The limited scope of this project did not permit an evaluation of the types and characteristics of biomass that may be available for use in American Samoa in a WTE facility.

Other Pacific Islands

Municipal solid waste management plans for the Northern Mariana Islands, Palau, the Federated States of Micronesia (Ponape, Truk,

Yap and Kosrae) and the Marshall Islands have been developed and provide some insight to MSW characteristics and quantities. However, available data is once again, sketchy at best.

Based on information from the various Solid Waste Management Plans for these islands, Table 4-5 presents estimates of per capita generation rates and the percentage of the MSW generated in these islands that would be combustible . Data for Guam, American Samoa, and Hawaii (source: Department of Planning and Economic Development, State of Hawaii) are included for comparison.

With respect to the applicability of waste-to-energy facilities in these islands, two major considerations are implied by the estimates given in Table 4-5. First, per capita MSW generation rates are significantly lower than estimated for Guam and American Samoa. Second, the percentage of the MSW that is combustible is generally lower due to a greater percentage of metal wastes in the MSW of these islands.

TABLE 4-5
MSW CHARACTERISTICS IN THE PACIFIC ISLANDS

<u>Island</u>	<u>MSW Generated (pcd)</u>	<u>Percent Combustible</u>
Hawaii	3.3 - 5.7	79
Saipan	2.3 - 3.23	_(1)
Moen, Truk	1.1	45
Ponape	1.33	55
Darrit-Uliga-Dalap, Majuro Marshall Islands	1.30	71

NOTE:

(1) Not available.

Given the lesser population on these islands relative to Guam and American Samoa, these two considerations imply that less energy is recoverable from the MSW streams generated in these islands. Further discussion of this implication is deferred to Chapter IX, "Viability Assessment", in which the overall feasibility of WTE facilities in the various Pacific Islands will be presented.

Summary

The MSW characteristics and quantities of MSW that will be assumed for Guam and American Samoa for the purposes of this study are as follows:

<u>Territory</u>	<u>TPD₇</u>	<u>Percent Combustible</u>	<u>Percent Moisture Content</u>	<u>Heating Value</u>
Guam	250	75	25-55	4,000 BTU/lb
American Samoa	100	75	25-55	4,000 BTU/lb

CHAPTER V

TECHNOLOGY REVIEW

General

A variety of technologies have been developed to recover energy and materials from municipal solid waste. This chapter presents an overview of the available techniques and processes and includes a general discussion of their applicability. The major areas addressed in this chapter include:

- o Material and energy recovery
- o Combustion equipment
- o Environmental control

In the next chapter, the technologies generally appropriate to the Pacific Islands and specifically to Guam and American Samoa will be discussed.

Material Recovery

The materials that can be recovered from a stream of municipal solid waste (MSW) include:

- o Ferrous metals
- o Aluminum
- o Heavy nonferrous metals
- o Glass

The most common materials recovered are ferrous metals and aluminum. If the project involves combustion of the solid waste, material recovery should occur prior to the combustor. This process is referred to as front-end processing. Some plants recover ferrous metal from the combustor ash, but at that point the materials' characteristics are altered and may not be suitable for certain uses. Postcombustion recovery of aluminum is difficult because the aluminum melts during the process and fuses to ash and other metals resulting in a contaminated

product. Removing these materials prior to combustion resolves these problems.

Front-end processing of MSW is generally performed for two reasons: material recovery and/or improvement of the fuel characteristics. The resulting improved fuel characteristics include lower ash content, increased heating value, more homogeneous composition, and reduced particle size.

Front-end processing can recover a number of materials from solid waste for recycling: ferrous metals, aluminum, heavy nonferrous metal, and glass. These materials can also be recovered by source separation and recycling centers. A number of communities, including Guam, have such programs.

The fuel product from a front-end processing system is termed refuse-derived fuel (RDF). The characteristics of RDF vary widely, depending on the type of processing. In the design of front-end processing systems, the RDF specification which is based on the combustion process that will utilize the fuel, is of great importance. Some combustion systems, in particular coal/RDF cofiring systems, have experienced premature wear due to abrasive material and problems of slagging from glass or other materials with low melting points. On the other hand, proper front-end processing can greatly improve the life of the system and reduce slagging problems.

The types of equipment that are used for front-end processing include:

- o Shredders
- o Classifiers
- o Screens and trommels
- o Material separators
- o Material handling equipment
- o Densifiers
- o Storage units

A system using these components for front-end processing is shown on Figure 5-1.

Much of the existing solid waste processing equipment has been derived from that developed for agricultural or food processing industries. Dry processing of materials such as grain, nuts, and wood presents problems similar to those of solid waste particularly as related to size reduction, screening, classification, transport, and storage. Many of the companies that market solid waste equipment also have had experience in agricultural and food processing.

One of the major problems that front-end systems have encountered is poor economics. A number of solid waste processing systems have been built that no longer operate due to economics and/or poor design. Many of these systems were complex and expensive to build and operate. In some cases, the systems recovered material for which an economic market was lacking. In other cases, the composition of the waste being processed changed, resulting in uneconomical operation. For example, at Ames, Iowa, passage of a beverage container deposit law reduced the aluminum and steel content of the waste. Aluminum, therefore, is no longer recovered at Ames.

The long-term prospects for the markets and production rates for recovered materials must be established as part of a feasibility study. Some processing systems that intended to sell RDF have not found any markets due to economic changes or problems with RDF utilization.

Some systems have encountered high maintenance costs due to component wear or low reliability. Other systems have had waste handling problems such as bridging, plugging, and low capacity

due to poor design and equipment selection. A number of systems have had explosions and fires, particularly in the shredder.

There is a general progression of increasing costs with increased RDF processing, i.e., better quality fuels can be produced at higher costs. What must be considered in the evaluation of front-end processing is the overall cost including the combustion system. Higher levels of front-end processing can be expected to allow the use of simpler and less costly combustion systems or allow the use of existing combustion equipment. The existence of markets for recovered materials can also affect the economics of front-end processing systems.

To achieve reliable operation in a front-end processing system, a number of components must be properly integrated. Thus, a systems approach should be used for design, and only firms experienced in design and construction of such systems should be employed.

In summary, the application of front-end equipment should include a thorough investigation of potential markets, and specifications should be established for both the RDF and recovered products. These criteria should be used in establishing the front-end system.

Energy Recovery

There are a number of methods to recover energy from MSW including:

- o Gasification
- o Pyrolysis
- o Combustion

Gasification and pyrolysis techniques are generally still in developmental stages and are currently not mature enough for consideration, particularly in the Islands and will not be

FIGURE 5-1
TYPICAL MATERIAL RECOVERY SYSTEM

considered further in this study. Direct combustion and heat recovery by steam generation is the most common form of energy recovery from solid waste. The steam is then used for thermal uses and/or power generation by expansion in a turbine-generator.

Combustion equipment designed to burn waste and recover useful energy has existed since 1896, and modern waste-burning equipment has been used since 1954. Until the 1970s, incineration of MSW without energy recovery was more economical than landfill disposal; now, as land becomes more expensive and as acceptable landfill sites are located further from waste generators, waste disposal systems using waste-to-energy technology may become economically advantageous.

The limited availability of land in Europe caused the development of waste-to-energy technology to advance faster there than in America. Many early American systems attempted to use this European technology. The initial attempts to use proven European technology in America were not completely successful because of differences in waste composition, equipment size, and lack of proper use of all elements of the European technology. In recent years, however, successful systems have been built using modified European technology. Also, systems have been built based on American technology and have operated with varying degrees of success. Generally speaking, larger systems have used European technology, and smaller systems have used either American or European technology.

Because of technological advances most problems with waste-to-energy systems have been overcome, and today reliable systems can be obtained. Potential problem areas that must be considered in the selection of an appropriate system include:

- o Corrosion
- o Erosion

- o Fouling of heat transfer surfaces
- o Feeding and movement of waste and ash
- o Changes in waste properties
- o Air and water pollution

As the technology has developed, a number of different approaches have been taken to the design of waste-to-energy combustion systems, and various types of combustion equipment are now commercially available.

Combustion Equipment

Waste-to-energy combustors are designed to either burn raw, unprocessed waste (mass burning) or refuse-derived fuel (RDF). RDF combustors can be dedicated or nondedicated. The former are designed specifically for RDF combustion and can burn 100 percent RDF. The latter are basically coal-burning combustors and usually are not considered suitable for burning more than 10 percent to 15 percent RDF based on heating value.

Figure 5-2 contains block flow diagrams showing the major differences between the mass-burning system and the RDF system. One of the major differences between the two systems is that in the context of a complete waste-burning plant, mass burning is less complicated than RDF. More specifically, the manner in which waste is fed to the combustors differs.

A mass-burning combustor is fed by a hydraulic ram or gravity chute. A combustor burning RDF is fed by a pneumatic spreader, which is part of a spreader-stoker system. Transportation of waste and ash within the combustors also differs. A mass-burning combustor agitates the waste and ash by mechanical means. A conventional RDF burning combustor moves the waste and ash without special agitation.

Aside from differences in the waste that is burned, combustors also differ with respect to the manner in which the heat of

MASS-BURNING SYSTEM

RDF SYSTEM

FIGURE 5-2
BLOCK FLOW DIAGRAMS
RDF AND MASS BURN SYSTEMS

combustion is captured. Combustors are categorized as either refractory-lined or waterwall.

Both the refractory-lined and the waterwall combustors have an outer metal shell and an inner layer of insulation. Both units also have an inner layer of dense, high-temperature refractory material. The major difference between the two is that the waterwall combustor has a wall composed of water-filled tubes. The tubes may or may not be coated with refractory material in the immediate area where most of the combustion occurs to protect them from excessive temperatures. The water flowing through the tubes captures energy and improves the overall efficiency of the waterwall combustor.

The standard refractory-lined combustor does not recover energy in the combustion chambers. Hot combustion gases leave these chambers, and heat is recovered in an auxiliary heat exchanger or waste heat boiler. This arrangement is thermally less efficient than the waterwall combustor but is considerably cheaper; however, the refractory-lined combustor frequently requires extensive maintenance. Waterwall combustors can operate with lower excess combustion air which results in more heat recovery.

The choice between refractory-lined or waterwall combustor is an economic one. The choice depends on the additional capital cost for a waterwall combustor as compared with the savings in maintenance costs and the additional revenue from the extra energy produced.

Environmental Control

A waste-to-energy plant has three emissions or discharges that must be controlled in order for the plant to be environmentally acceptable:

- o Air emissions
- o Liquid discharges
- o Ash

The major air pollutants emitted by waste-to-energy plants include particulates, sulfur dioxide and acid gases, nitrogen oxides and hydrocarbons including carbon monoxide.

Liquid discharges from the plant include not only sanitary wastewater but also process waters such as wastes from floor washdown, equipment cleanup and vehicle maintenance, boiler make-up water, boiler blowdown, and condenser cooling water.

Ash is the solid residue left when combustible material is thoroughly burned. The quantity of ash produced by the plant will depend on the composition of the material fed to the combustor and the completeness of the combustion.

In general, environmental pollution control can be accomplished through technological means. For example, the formation of air contaminants can be reduced and the remaining contaminants can be captured. Sanitary wastes can be discharged to existing sanitary wastewater systems. Other process waters can be recycled or reused, and ash can be disposed in approved landfill areas. The technological means for controlling environmental pollution are the focus of the remaining sections of this chapter.

Air Pollution Control

As mentioned earlier, the major air pollutants emitted by waste-to-energy plants are:

- o Particulates
- o Sulfur dioxide and acid gases
- o Nitrogen oxides
- o Hydrocarbons and carbon monoxide

A wide variety of equipment is available that can reduce the formation of or capture air contaminants before they are released

to the atmosphere. In general, each type of equipment is designed to control a specific pollutant although some devices such as wet scrubbers, dry scrubbers, and baghouses can be used to capture several pollutants. A wet scrubber can remove particulate as well as sulfur dioxide and acid gases. The combination of a dry scrubber and baghouse can also be used to remove these pollutants.

Pollution control devices include flue gas treatment systems, which remove the pollutants from the exhaust gases and controlled combustion systems, which reduce the formation of some pollutants during the combustion process itself. Particulate matter, sulfur dioxide, and acid gases are generally controlled by flue gas treatment systems, while controlled combustion systems are used to reduce nitrogen oxides, hydrocarbons, and carbon monoxide.

Particulate Control - Five basic devices are available to remove particulates from flue gas; these can be used singly or in combination:

- o Baghouse (fabric filters)
- o Electrostatic precipitator
- o Cyclone separator
- o Gravel bed filter
- o Wet scrubber

Particulate filtration in baghouses (fabric filters) is accomplished by passing the flue gas through cylindrical or oblong bags of fabric. As the gas passes through the fabric, the particulate material is retained by the fabric and builds up a filter cake. Periodically, this filter cake must be removed to prevent the pressure drop across the baghouse from becoming excessive.

Electrostatic precipitators (ESP) have been extensively used for particulate removal on coal-fired boilers and on most, if not

all, large waste-to-energy facilities here and in Europe. They are almost exclusively used for large coal-fired utility boilers. These units collect particulates on plates by means of a high voltage field produced between the electrodes. Dust collected by the unit is removed by vibrating the plates and electrodes with a rapper system. The dust falls off the plate and into the hoppers at the bottom of the unit. Performance of an ESP is dependent on the particulate size, loading, and ash resistivity.

Cyclones are devices that remove particulate material by centrifugal action. They can remove large material effectively but are inefficient on small material (under about 10 microns). Alone, cyclones cannot meet present emission requirements, but they are often used upstream of other control devices to decrease the particulate load fed to those devices. Reducing inlet loading may improve the efficiencies of final control devices by decreasing emissions, physical size, or maintenance. Cyclones have low initial cost and moderate operating and maintenance costs.

The gravel bed filter is a relatively new device for particulate emission control. The filter unit consists of a bed of gravel contained between two steel louver walls. The dirty flue gas passes through the louvered walls and the gravel bed removes the particulate material. The filter bed is continuously drained from the bottom of the unit and lifted to the top of the unit, cleaned, and returned to the filter bed. The dust is carried by the air stream to a small baghouse where it is collected. A high voltage is also produced on a grid in the gravel bed to enhance the collection efficiency of fine particles. The advantage of these units is that they are not as sensitive to ash loading, acids, and process upsets (temperature excursions) as are bag filters. The gravel bed filter has moderate initial operating and maintenance costs.

Wet scrubbers can also be used for particulate emission control. The main application of these devices in waste-to-energy plants is in conjunction with suppression of sulfur oxides and acid gases. This application is discussed in the section on sulfur dioxide and acid gas control. Wet scrubbers have low initial and maintenance costs but high operating cost due to high pressure drops.

Sulfur Dioxide and Acid Gas Control - To control emissions of sulfur dioxide and acid gases such as hydrogen chloride and hydrogen fluoride, different equipment is required than that for control of particulates only. Under present regulations of the US Environmental Protection Agency (EPA) control of these pollutants is not required in waste-to-energy plants; however, some countries and states, such as California, require their control. The following discussion is included for this reason.

Two major types of equipment are used in controlling these pollutants: wet scrubbers and dry scrubbers. The wet scrubber has long been used for gaseous emission and particulate control. The most common wet scrubber for waste-to-energy plants uses a gas-atomized spray and is termed a venturi scrubber. In this unit the liquid is atomized by the flue gas which is accelerated to a high velocity by the venturi nozzle. Dust is captured in the liquid droplets: a cyclone separator removes the large droplets, and a mist eliminator removes small liquid droplets.

When a wet scrubber is to be used to control oxides of sulfur and acid gases, lime or soda ash is added to the scrubbing liquid. These alkaline chemicals react with the acid gases, and 90% removal is usually possible.

The dry scrubber is used to control the same gaseous emissions, i.e., oxides of sulfur and acid gases. In the dry scrubber system, the reagent is sprayed in liquid slurry form into the flue gas in a spray dryer. The slurry droplets are completely

vaporized, and the reagent reacts with the gaseous pollutants to form solid particulate material. This material is collected by a downstream particulate collection device, usually a baghouse (but sometimes an ESP). The reagents used in the dry scrubber are the same as those used in the wet scrubber, lime or soda ash. No further particulate emission control devices are required because the device used in the dry scrubber system can capture the combustor particulate matter as well as that generated in the spray dryer.

Nitrogen Oxides Control - The emission of nitrogen oxides is not as severe a problem in waste-to-energy systems as in higher temperature combustion processes. In high temperature combustion, the major source of nitrogen oxide is fixation of atmospheric nitrogen and oxygen from the combustion of air. This reaction is a function of combustion temperature, and nitrogen oxide production is high with low moisture fuels and low excess air. Solid waste has a relatively high moisture content and usually requires more excess air than a more homogeneous, drier fuel. Consequently, combustion temperature is relatively low, and nitrogen oxide production is less than with other fuels.

A number of methods have been devised to lower nitrogen oxide emissions in a combustion process, most of which involve reducing combustion temperatures. One method used is staged combustion, i.e., combustion is accomplished in two distinct phases that produce less nitrogen oxide due to a lower peak temperature. Flue gas recirculation is another method of nitrogen oxide control in which peak combustion temperature is reduced. In this system, flue gas is taken from the downstream side of the combustor and injected into the combustion zone.

It should be noted that the control of nitrogen oxide production often runs counter to high combustion efficiency and control of other pollutants. For example, carbon monoxide and hydrocarbons are minimized by high temperature and long residence time. The

total combustion process and desirable tradeoffs must be considered when design decisions are made to control specific pollutants.

Nitrogen oxide can also be produced from nitrogen that is introduced as part of the fuel. This source of nitrogen oxide cannot be controlled by the same methods as thermal nitrogen oxide (formed from combustion of atmospheric nitrogen) because lowering combustion temperature has little effect on its formation. Postcombustion control methods, however, show promise for controlling both thermal and fuel nitrogen oxide.

One postcombustion method of nitrogen oxide control that has been considered for waste-to-energy projects is ammonia injection such as that employed in the Exxon Thermal DeNO_x. This postcombustion process uses ammonia to convert the nitrogen oxide back to nitrogen and oxygen in a reducing action. For this process to work effectively, the proper quantity of ammonia must be injected within a narrow band of flue gas temperatures.

Hydrocarbon and Carbon Monoxide Control - Waste-to-energy combustion systems are also potential emitters of large quantities of hydrocarbons and carbon monoxide due to the heterogeneous nature of the waste, the intermittent feed systems on some units and use of unregulated combustion temperature and air on some units. These pollutants are best controlled by good design of the combustor. In order to complete combustion of hydrocarbons and carbon monoxide, the combustor must have adequate oxygen content, mixing and residence time, and temperature level to complete the oxidation reactions.

Wastewater Control

The wastewater resulting from the waste-to-energy plant operation may derive from several potential sources including:

- o Tipping floor washdown, equipment cleanup and vehicle maintenance

- o Boiler make-up water treatment
- o Boiler blowdown
- o Sanitary wastewater
- o Condenser cooling water

Generally, wastewaters (except sanitary wastewater) are reused in the plant for ash quenching and dust suppression. Sanitary wastewater is normally discharged to the municipal sanitary system.

Condenser cooling systems can be designed for open loop or closed loop. In an open loop design, the cooling water from the condenser is used in a "once-through" process and is discharged back to the cooling water source (i.e. a cooling pond, river, ocean). In a closed loop system or recirculating system, a cooling tower is normally used. Water from the cooling tower basin, referred to as cooling tower blowdown, is discharged to maintain the water chemistry to prevent scaling/corrosion of the condenser tubes. In waste-to-energy plants, cooling tower blowdown could also be recycled in the plant.

Ash Disposal

Ash is the solid residue left when combustible material is thoroughly burned. The quantity of ash produced will depend on the composition of the material fed to the combustor and the completeness of combustion. Upon complete combustion, typical MSW streams will have an ash content of 15-30 percent by weight. Incomplete combustion can significantly raise the amount of ash production. Front-end processing can reduce the amount of combustion process ash by removing metal, glass, grit, and ceramics, but the rejects from front-end processing still require disposal. Some of these materials, such as ferrous metal or aluminum, can be recycled thereby reducing the amount of front-end rejects.

Figure 5-3 illustrates a waste-to-energy system and the points at which ash can leave the system. The two major types of ash in this system are bottom ash and fly ash. Bottom ash is the ash that is removed from the bottom of the combustor. It constitutes about 85-95 percent by weight of the total ash in a mass-burn system. Bottom ash is coarse and heavy, may contain clinkers and usually stays on the grate during combustion. In a unit with a moving grate, bottom ash is discharged from the end of the grate, often dropping into a water quench.

FIGURE 5-3
ASH REMOVAL POINTS IN WASTE-TO-ENERGY SYSTEMS

Fly ash is that material which is carried out by the hot gas stream, i.e., "flies" out of the combustor. It constitutes about 5-15 percent by weight of the total ash in a mass-burn system. Another common term for fly ash is particulate material. As shown on Figure 5-3 fly ash is collected at various points. The first point of collection is the convection section of the boiler, if used. Following this equipment there could be a spray dryer where a reagent slurry is sprayed into the gas steam for removal of sulfur dioxide, acid gas, and some particulate. The next possible ash removal point is the cyclone separators or multiclones, if used. The final ash removal point is a particulate removal device such as a baghouse, electrostatic precipitator, wet scrubber, or gravel bed filter as previously described.

The size and composition of ash will vary with the collection point. In a combustion process, segregation of the fly ash will occur because the fly ash, which normally has smaller particle than bottom ash, is carried out of the combustor by the combustion gases. As the fly ash progresses through the train of equipment, the coarser particles are removed first, and the latter stages are designed to capture the finer, more difficult to remove particles. Ash collection and handling systems can be classified as wet or dry, depending on whether or not they use water.

In a dry system, the ash is gathered in hoppers located under the collection device and transported by a pneumatic conveyor system to an ash silo. A separation device, usually a cyclone separator, removes the fly ash from the transport gas. Some type of gas seal, either a feeder valve or an air-lock system, is required between the hopper and the transport line. In some combustion systems using relatively clean fuel, the bottom ash can also be transported dry after passing through a clinker grinder that reduces the material size sufficiently for it to be transported pneumatically. Grinding is not usually performed in

mass-burn systems because of the metals and abrasive materials, which would cause wear of the clinker grinder.

In a wet system, the ash is immediately wetted and transported to a settling pond by a liquid transport system. Jet pumps are used to draw ash into a stream of flowing liquid. As with the dry system, clinker grinders can be used, if bottom ash is handled by this system. Periodically, the ponds are pumped out and possibly allowed to air dry. The ash sludge is removed by a dragline or front-end loader and hauled to landfill by trucks. Water required for a wet ash system may come from sources such as boiler blowdown, drains, and cooling tower blowdown. In order to conserve water, the ash system water is recycled as much as possible. Advantages of the wet system include the elimination of fire hazard and dust problems.

A variation of the wet system uses water-filled tanks and drag conveyors. The ash drops into the tanks, is quenched, dragged up the tank incline, and deposited onto another conveyor which carries it to a holding receptacle. This type of system is often used for bottom ash and can be used for fly ash. An advantage of this system is a low rate of water consumption. Some water is evaporated from the tanks as the hot ash is quenched, and some is carried out with the ash, but less water is used than with a conventional wet ash system that requires evaporation ponds or a water discharge.

Transportation of ash is usually performed by open dump trucks, if the ash is sufficiently moist to eliminate the dust problem. If dry ash is to be transported, a covered truck must be used for dust control. Bulk transport units like those used for cement can be used.

CHAPTER VI

APPROPRIATE TECHNOLOGY

General

As presented in Chapter V, there are various techniques, processes, and equipment available for developing a waste-to-energy conversion facility. Because not all of these techniques and processes are appropriate for the Pacific Islands, this chapter will limit itself to a discussion of the technologies appropriate for the Pacific Islands, in general, and Guam and American Samoa, in particular. A presentation of the conceptual waste-to-energy facilities for Guam and American Samoa will also be provided. These facilities, as described in this chapter, will form the basis for the assessment of the viability of waste-to-energy conversion programs in the two islands.

Technologies for the Pacific Islands

In developing a conceptual waste-to-energy facility for the Pacific Islands, three basic technological decisions must be made:

- o The extent of front-end processing to which the MSW will be subjected;
- o The form in which the energy product will be utilized; and
- o The method by which the process will be cooled.

As will be shown in the following discussion, these three technological decisions are directly related to the broad environmental characteristics of the Pacific Islands. Specifically, the decisions are dependent on economic and

infrastructural conditions as well as the physical environment in the islands.

Waste-to-energy systems employing front-end processing of the MSW do not appear to be appropriate for the Pacific Islands. Front-end processing systems can significantly increase capital, operating, and maintenance costs. These systems are complex, using equipment such as trommels, shredders, air classifiers, conveyors, metal separators, and storage. Material recovery is normally economical if a local market exists to purchase the recovered materials. Moreover, such markets for recovered materials are often volatile as evidenced by the low prices during the recent economic downturn.

In general, markets for recycled materials do not exist on the Pacific Islands. Aluminum has been a recovered product with high value but changing conditions such as home recycling programs or beverage container deposit laws can dramatically decrease the aluminum content of the MSW stream. Thus, in remote locations such as the Pacific Islands it may be more cost effective to implement source separation for selected materials, for example, ferrous metal and aluminum (presently done on Guam). Therefore, it presently does not appear feasible to incorporate front-end material recovery in waste-to-energy facilities located in the Pacific Islands.

This initial decision regarding front-end material recovery in a waste-to-energy plant determines whether it will be a mass burn or a RDF plant. As discussed in Chapter V, an RDF plant burns waste which has been processed prior to combustion to remove non-combustible material such as metal and glass, thereby reducing material size. Although the resulting fuel is easier to feed and burns more completely, the front-end processing equipment is expensive to build and operate and usually becomes justified only if material recovery is economical. A mass burn system on the other hand will combust the solid waste without any processing

prior to combustion, except for the removal of oversized or hazardous items. In a mass burn plant, the degree of combustion is improved by a system that agitates the waste as it moves through the combustor over reciprocating grates, rotating combustors, or other devices that tumble and agitate the waste as it burns. In summary, mass burn units appear to be the best choice for the Pacific Islands since they are simpler and less costly and because of the apparent absence of a recovered materials market.

The energy products of any waste-to-energy system fall into two broad areas: thermal energy (steam or hot water) and electricity. The drawback to thermal energy is that it cannot be transported long distances, requiring the user to be close to the waste-to-energy plant. Also, the thermal load should be fairly constant and of long duration so the plant can be base loaded. A waste-to-energy plant does not lend itself to rapid load changes and requires high utilization to be economical.

Supplying thermal energy with a waste-to-energy plant in the Pacific Islands can be feasible if the plant can be located near a thermal load that would allow the plant to be base loaded. These type of conditions will be hard to find in the Islands, but each case must be individually evaluated. In Guam's case, the Guam Oil Refining Co. generates its own steam and has no further need for it. In American Samoa, the fish canneries use steam but there are no potential sites close enough to make this use practical. Another option for use of the energy would be to use the thermal energy in an existing thermal power plant. This approach is attractive since it would save the cost of the turbine-generator, condenser, and cooling system. In order to use the thermal energy in a utility steam cycle a number of items must be considered:

- o Available site
- o Effect on existing cycle and equipment
- o Effect on utility plant reliability

For a utility plant tie-in to be viable, there must be a site available close to an existing utility plant. Furthermore, the utility plant must be operating as a base load plant since the waste-to-energy plant must have a high capacity factor to be economical. In the case of Guam, there is a site available close to the Cabras power plant and this plant is base loaded making it an excellent candidate for utility tie-in. But, the effect of feeding the waste-to-energy thermal product into the thermal cycle and equipment of the existing utility plant must be assessed.

Because of superheater corrosion, a waste-fired, power plant boiler is designed with lower temperature steam conditions than an oil-fired boiler. Typically, a waste-fired power plant boiler is designed to produce 600 psig, 750°F steam whereas a conventional oil-fired boiler produces 1800 psig, 1000°F steam. Consequently, the steam from a waste-fired system cannot be directly mixed with the conventional boiler output, due to the difference in conditions. Another possibility for use of the thermal energy from a waste-to-energy facility is to use the steam for feedwater heating in a conventional power plant in place of extraction steam from the turbine. This approach must be carefully reviewed to establish the effect on the turbine cycle and equipment. Turbine manufacturers such as General Electric, in general, do not recommend operation with feedwater heaters out-of-service except for emergency operation (less than 100 to 200 hrs).

The relative sizes of the two systems are also important since a small waste-to-energy system tied into a large utility system will have much less effect than the converse. Another possible utility tie-in would be to admit the waste plant steam ahead of the boiler reheat section, but again, such a proposal must be

analyzed to establish the effect on the turbine, boiler, and control system.

The various possibilities for using the thermal products of a waste-to-energy facility in a conventional utility plant must also be carefully reviewed to insure that the reliability of the conventional utility plant is not affected and that the utility can continue to operate if the waste-fired system is out of service.

Given the above considerations and problems related to use of the thermal energy obtained from waste-to-energy facilities, electricity is the more viable energy product. This form of energy is usually distributed through the existing electrical transmission system and, therefore, locating the waste-to-energy plant will not be constrained by the need to be in close proximity to other facilities. However, an electricity-generating waste-to-energy plant will be more costly because of additional equipment requirements and a more expensive boiler due to higher pressure and temperature conditions for the steam.

The third major technological decision is related to the method by which the waste-to-energy process will be cooled. The overriding consideration in making the technological decision is the availability of seawater for a cooling system. Most islands in the Pacific are relatively small so that access to seawater for cooling systems is not a problem. As a matter of fact, the Cabras power plants on Guam already utilize seawater in their cooling systems, and the existing cooling water channel could be readily utilized for the waste-to-energy facility.

Based on the foregoing discussion, the most applicable type of waste-to-energy plant for the Pacific Islands is one that has the following characteristics:

- o Mass burning of MSW;
- o Generation of electricity only; and
- o Use of seawater for cooling

Conceptually, the waste-to-energy process would proceed as schematically shown on Figure 6-1. A plant using such a process would be applicable to both Guam and American Samoa. The general layout and configuration of such a plant is shown on Figure 6-2. The various stages of the process are briefly described in the following paragraphs.

Receiving and Handling of Waste - Trucks will carry waste material to the plant and, on entering the plant site, will proceed to a scale for weighing. After weigh-in, the trucks will proceed to the tipping floor building where they will dump directly to the MSW storage pit. It should be noted that if oversized wastes, e.g. refrigerators, sofas, chairs, etc., are processed, they would be separated out in the tipping floor building and either removed to a landfill or shredded by rip-shear shredders. However, the processing of such waste in the Pacific Islands will not be considered in this study.

From the MSW pit, material is picked up and deposited into the feed hopper of the combustor using the crane.

MSW Combustor Description and Operation - Combustion of the MSW in this design would be accomplished in a water wall type of rotary combustor (the O'Connor combustor). This unit has been selected for the study because among the mass-burning units it is one of the more efficient for power production and has been demonstrated in a similar application (Gallatin, Tennessee). It should be noted, though, that this selection is made only for the purpose of this study and is thus only a preliminary conceptual selection.

The combustor unit consists of a long rotating inner cylinder which is coaxial with an outer stationary cylinder. MSW is ram-

FIGURE 6-1
PROCESS FLOW DIGRAM
WASTE-TO-ENERGY FACILITY
FOR THE PACIFIC ISLANDS

FIGURE 6-2
GENERAL LAYOUT AND CONFIGURATION
OF TYPICAL WASTE-TO-ENERGY PLANT
FOR THE PACIFIC ISLANDS

fed into the upper end of the inner cylinder and moves slowly through the unit because of the unit's tumbling action and slight declination. Combustion air at about 450°F is forced through the porous wall of the inner cylinder and through the pile of MSW tumbling on that wall. The wet MSW first dries and then burns, releasing its heat of combustion. Because of the water tubes of the inner cylinder, very little of this heat is lost to the environment.

The water tubes, the forced air, and the tumbling motion of the inner cylinder prevents sintering and/or sticking of the hot ash. Some of the ash produced drops through the holes in the inner wall and ultimately falls into a water-filled quench bath. The rest of the ash exits from the lower end of the rotary combustor.

Steam Generation and Use - The lower end of the rotary combustor is connected to a boiler/superheater. Ash entering the lower end of the combustor falls onto a water-cooled grate, is combusted further, and eventually falls into the water-filled quench bath. Hot combustion gas (flue gas) from the rotary combustor rises past the heat exchange tubes of the boiler/superheater and gives up most of its heat to the partially heated water from the water tubes of the rotary combustor. Steam at 750°F and 600 psig is therefore generated. Required make-up water is obtained by demineralization of available water supplies.

Before leaving the boiler/superheater, the flue gas, which will still be relatively hot at about 600°F, is used to heat the combustion air. This final exchange of heat helps bring the cold combustion air to a temperature of 450°F as it enters the rotary combustor, thus increasing the thermal efficiency of the system. The relatively cool 400°F, flue gas exits the boiler/superheater and passes through the pollution control equipment.

At this point in the process, all practically recoverable energy from combustion of the MSW is in the generated steam. Useful

energy in the steam is converted to electricity. This is accomplished by expanding the steam through a multistage condensing turbine. The steam is then condensed and returned to the boiler.

Environmental Control - As mentioned in Chapter V, environmental control covers three areas:

- o Air emissions
- o Waste water discharges
- o Ash collection

Because of the lack of industrial development, low population density, and open terrain, the Pacific Islands do not, in general, have an air pollution problem. An exception is Cabras Island on Guam which is a nonattainment area for sulfur dioxide due to the oil-burning power plants. It should be noted though that the Government of Guam has recently been granted an exemption and waiver to enable them to use high sulfur fuel in their power plants. The waste-to-energy plant will be in compliance with the EPA New Source Regulations for waste-fired units.

In the typical waste-to-energy facility for the Pacific Islands, air emissions from the stack would be controlled by a combination of combustion design and stack gas clean-up. Emissions of carbon monoxide, hydrocarbons, and oxides of nitrogen would be controlled by design of the combustion system. Particulate emissions would be controlled by a combination of cyclone separators and baghouses. The cyclones would be placed ahead of the baghouses to remove the larger size particulates and provide protection to the baghouse from burning embers that can otherwise damage the bags. The baghouse provides a good efficiency in collection of particulates and is not as sensitive to changes in the process as an electrostatic precipitator could be.

As mentioned before, most of the wastewater resulting from the waste-to-energy plant operation is not discharged. The two streams that would be discharged from the facility would be the once-through cooling water and the sanitary wastewater. The once-through cooling water can be discharged to the ocean and the sanitary wastewater to the municipal sanitary sewer system. The wastewater from the proposed facility can also be reused in the plant for ash quenching and dust suppression.

With respect to ash control measures within the proposed waste-to-energy process, hot ash from the rotary combustor and boiler/superheater would fall into a water bath, where it is quenched. This bath also seals the boiler/superheater from the atmosphere and allows continuous ash removal by means of a submerged ash conveyor. Ash from the flue gas stream beyond the flue gas-combustion air heater exchanger would be relatively cold and may be handled without water quench. Some of this ash would drop out of the flue gas stream at this point in the process, and most of the rest would be trapped as the flue gas passes through the particulate removal device.

Waste-to-Energy Plant for Guam

The foregoing generalized description of the waste-to-energy process and typical plant configuration may now be specifically discussed with respect to conditions and site features in Guam and American Samoa. The remainder of this chapter focuses on the application of this waste-to-energy technology on the two Islands that are the direct subjects of this study. The waste-to-energy plant proposed for Guam would be a 250 ton per day (TPD) waste-fired electricity plant and would be located on lot 265-2, just north of Cabras Road and west of the existing power plant cooling water channel as shown on Figure 6-3. The Cabras Island site was selected for the following reasons:

- o Close proximity to cooling water;
- o Located in an industrial area;
- o Located close to an existing power plant which facilitates electrical tie-in and possible utility tie-in; and
- o Possibility of sharing skilled personnel from existing power plant.

A single combustor configuration has been selected for this plant in order to reduce the capital investment as much as possible. Although this reduces plant availability, that problem is not a major consideration on Guam since the Island has excess oil-fired generating capacity.

An assessment of the waste quantity and heating value available on Guam indicated that the plant should be designed for 250 TPD with a heating value of 4,000 BTU/lb. The mass and energy flow rate for the plant are shown in Table 6-1. The stream numbers in Table 6-1 refer to the stations in the process flow diagrams shown on Figure 6-1. The plant conditions are shown at a nominal flow of 250 TPD on a seven day basis (or 350 TPD on a five day basis), the typical collection schedule. At these conditions the gross generator output would be 4,464 kW and the net output, 3,928 kW. Boiler steam conditions would be 600 psig and 750°F. The combustor would operate at 50 percent excess air and a stack temperature of 400°F. Condenser cooling would be accomplished using seawater at 80°F and condenser pressure would be 2.5 inches HgA. Ash would be disposed of at the landfill at a rate of 59.2 TPD on a seven day basis. Table 6-2 presents a list of major equipment and a brief description of each item.

Waste-to-Energy Plant for American Samoa

The waste-to-energy plant for American Samoa would be a 100 TPD waste-fired electricity plant to be located just east of the Tafuna Power Plant as shown on Figure 6-4. This site was selected for the following reasons:

VICINITY MAP

LEGEND

- A TRUCK SCALE
- B SCALE HOUSE
- C PARKING LOT
- D TIPPING FLOOR
- E REFUSE STORAGE PIT
- F ROTARY COMBUSTOR AND BOILER ROOM
- G TURBINE ROOM
- H BAGHOUSE
- I STACK
- J TRUCK ENTRY AND EXIT
- K ADMINISTRATION BUILDING
- L WASTEWATER TREATMENT BUILDING
- M WATER TREATMENT BUILDING
- N POTABLE AND FIRE WATER STORAGE TANK
- O UNDERGROUND FUEL OIL STORAGE TANK
- P ELECTRICAL EQUIPMENT PAD
- Q ASH STORAGE

FIGURE 6-3
CONCEPTUAL SITE PLAN
GUAM WTE FACILITY

TABLE 6-1
VALUES OF STREAMS SHOWN ON FIGURE 6-1 FOR A
250 TPD₇ WASTE-TO-ENERGY PLANT FOR GUAM

Stream Number	Stream Description	Flow Rate (lb/hr)	Ash (lb/hr)	Moisture (lb/hr)	Energy (Btu/lb)	Energy ⁽¹⁾ (mmBtu/hr)
1	Primary Waste In	350 TPD ₅ ⁽²⁾	70 TPD ₅ ⁽²⁾	116 TPD ₅ ⁽²⁾	4000	--
2	Secondary Waste In	0	0	0	0	0
3	Primary Waste to Combustor	20833	4167	6875	4000	83.3
4	Secondary Waste to Combustor	0	0	0	0	0
5	Total Fuel to Combustor	20833	4167	6875	4000	83.3
6	Combustion Air	93655	0	281	0	0
7	Flue Gas	111811	1600	13330	209	23.4
8	Cleaned Flue Gas	110214	3.2	13330	209	23.4
9	Ash From Baghouse	1597	1597	0	80	0.1
10	Cooled Boiler Ash	3333	2667	667	27	0.1
11	Steam to Turbine	47764	0	47764	1380	65.9
12	Generator Output	4464 kW	N/A	N/A	N/A	15.2
13	Steam to Condenser	42034	0	42034	1027	43.2
14	Feedwater to Boiler	42197	0	42197	218	10.7
15	Ash Cooling Make-up Water	1200	0	1200	0	0
16	Boiler Blowdown	1433	0	1433	475	0.7
17	Turbine Extraction Steam	5730	0	5730	1280	7.3
18	Primary Pit Clean-up Water	208	0	208	0	0
19	Secondary Pit Clean-up Water	0	0	0	0	0
20	Ash to Landfill	59.2 TPD ₇ ⁽³⁾	51.2 TPD ₇ ⁽³⁾	8.0 TPD ₇ ⁽³⁾	0	0
21	Cooling Water In	2,662,000	0	2,662,000	48	127.8
22	Cooling Water Out	2,662,000	0	2,662,000	63	167.7

Notes:

- (1) Energy datum for steam and condensate is 32°F water; for other streams 77°F.
- (2) TPD₅ - ton/day based on five day/week waste delivery.
- (3) TPD₇ - ton/day based on seven day/week operation.

TABLE 6-2
MAJOR EQUIPMENT LIST
GUAM PLANT - 250 TPD

<u>Equipment Item</u>	<u>Description</u>	<u>Equipment Item</u>	<u>Description</u>
Bridge Crane with Bucket	2 ton capacity, 60 ft span, all electric, 3 cubic yd bucket.	Induced Draft Fan	46,000 ACFM at 400F, 15 in water pressure rise
Turbine Room Crane	5 ton capacity, 30 ft span, 25 ft lift	Baghouse	46,200 ACFM at 400F, loading 3.0 gr/SCF at 12% CO ₂
Rotary Combustor	300 TPD MSW, 100 Million Btu/hr heat release, excess air 50%	Boiler Feed Pumps (2)	30,000 lb/hr, 750 psi differential
Boiler	56,500 lb/hr steam production at 600 psig and 750F, feedwater 250F, efficiency 65.6%	Deaerator	120 gpm 15 psig
Air Heater	Air flow 104,600 lb/hr, flue gas flow 126,000 lb/hr, air out 450F, gas out 400F	Turbine Generator	55,000 lb/hr throttle flow at 600 psig and 750F, exhaust pressure 2.5 in HgA, generator 5500 KW.
Forced Draft Fan	23,300 SCFM at 70F, 10 in water pressure rise	Condenser	50,000 lb/hr steam flow, at 1028 Btu/lb, 48 million Btu/hr thermal load, 6300 gpm cooling flow, 15F temperature rise

TABLE 6-3
VALUES OF STREAMS SHOWN ON FIGURE 6-1
100 TPD₇ WASTE TO ENERGY PLANT FOR AMERICAN SAMOA

Stream Number	Stream Description	Flow Rate (lb/hr)	Ash (lb/hr)	Moisture (lb/hr)	Energy (Btu/lb)	Energy ¹ (mmBtu/hr)
1	Primary Waste In	140 TPD ₅ (2)	28 TPD ₅ (2)	46 TPD ₅ (2)	4000	--
2	Secondary Waste In	0	0	0	0	0
3	Primary Waste to Combustor	8333	1667	2750	4000	33.3
4	Secondary Waste to Combustor	0	0	0	0	0
5	Total Fuel to Combustor	8333	1667	2750	4000	33.3
6	Combustion Air	37458	0	112	0	0
7	Flue Gas	44725	640	5332	209	9.4
8	Cleaned Flue Gas	44086	1.3	5332	209	9.4
9	Ash from Baghouse	639	639	0	80	0.1
10	Cooled Foiler Ash	1333	1067	267	27	0
11	Steam to Turbine	19105	0	19105	1380	26.4
12	Generator Output	1786 kW	N/A	N/A	N/A	6.1
13	Steam to Condenser	16815	0	16815	1027	17.3
14	Feedwater to Boiler	19679	0	19679	218	4.3
15	Ash Cooling Make-up Water	480	0	480	0	0
16	Boiler Blowdown	573	0	573	475	0.3
17	Turbine Extraction Steam	2290	0	2290	1280	2.9
18	Primary Pit Clean-up Water	83	0	83	0	0
19	Secondary Pit Clean-up Water	0	0	0	0	0
20	Ash to Landfill	23.7 TPD ₇ (3)	20.5 TPD ₇ (3)	3.2 TPD ₇ (3)	0	0
21	Cooling Water In	1,065,000	0	1,065,000	48	51.1
22	Cooling Water Out	1,065,000	0	1,065,000	63	67.1

Notes:

- (1) Energy datum for steam and condensate is 32 F water; for other streams 77 F.
- (2) TPD₅ - ton/day based on five day/week material delivery.
- (3) TPD₇ - ton/day based on seven day/week operation.

TABLE 6-4
MAJOR EQUIPMENT LIST
AMERICAN SAMOA PLANT - 100 TPD

<u>EQUIPMENT ITEM</u>	<u>DESCRIPTION</u>	<u>EQUIPMENT ITEM</u>	<u>DESCRIPTION</u>
Bridge Crane with Bucket	1 ton capacity, 50 ft span, all electric 1.5 cubic bucket	Induced Draft Fan	21,700 ACFM at 400F, 15 in water pressure rise
Turbine Room Crane	2.5 ton capacity, 25 ft span, 20 ft lift	Baghouse	21,700 ACFM at 400F, loading 3.0 gr/SCF at 12%
Rotary Combustor	140 TPD MSW, 47 million Btu/hr heat release, excess air 50%	Boiler Feed Pumps (2)	15,000 lb/hr, 750 psi differential
Boiler	23,300 lb/hr steam production at 600 psig and 750F, feedwater 250F, efficiency 65.6%	Deaerator	60 gpm, 15 psig
Air Heater	Air flow 48,800 lb/hr, flue gas flow, 59,000 lb/hr, air out 450F, gas out 400F	Turbine Generator	25,000 lb/hr throttle flow at 600 psig and 750F, exhaust pressure 2.5 in HgA, generator 2400 KW
Forced Draft Fan	10,900 SCFM at 70F, 10 in water pressure rise	Condenser	22,000 lb/hr steam flow at 1028 BTU/lb, 21 million BTU/hr thermal load, 2800 gpm cooling flow at 15F temperature rise

- o Located close to the existing power plant which facilitates electrical tie-in and allows sharing of skilled personnel;
- o Located close to the proposed industrial park; and
- o Lack of an acceptable site near the canneries.

As with the Guam plant, a single combustor configuration has been selected in order to minimize the capital expenditure. Since American Samoa does not have excess generating capacity, as Guam does, it may be desirable to provide redundancy in the system in order to provide greater reliability/availability. This should be considered in the preliminary design phase of the project.

An assessment of the quantity of waste and the estimated heating value available on American Samoa indicated that the plant should be designed for 100 TPD of waste with a heating value of 4000 BTU/lb. The mass and energy flow rates for the plant are shown in Table 6-3. Once again the stream numbers in Table 6-3 refer to the stations in the process flow diagram shown on Figure 6-1. The plant conditions are shown at a nominal flow of 100 TPD on a seven day basis (or 140 TPD on a five day basis). At these conditions the gross generator output would be 1786 KW and the net output, 1,572 KW. Boiler steam conditions would be 600 psig and 750°F. As with the Guam design, the combustor would operate at 50 percent excess air and a stack temperature of 400°F. Condenser cooling would also be accomplished with sea water at 80°F and condenser pressure would be 2.5 inches HgA. Ash would be disposed of in a landfill at the rate of 23.7 TPD on a seven day basis. Table 6-4 presents a list of major equipment and a brief description of each item.

VICINITY MAP

61-19

LEGEND

- A TRUCK SCALE
- B SCALE HOUSE
- C PARKING LOT
- D TIPPING FLOOR
- E REFUSE STORAGE PIT
- F ROTARY COMBUSTOR AND BOILER ROOM
- G TURBINE ROOM
- H BAO HOUSE
- I STACK
- J TRUCK ENTRY AND EXIT
- K ADMINISTRATION BUILDING
- L WASTEWATER TREATMENT BUILDING
- M WATER TREATMENT BUILDING
- N POTABLE AND FIRE WATER STORAGE TANK
- O UNDERGROUND FUEL OIL STORAGE TANK
- P ELECTRICAL EQUIPMENT PAD
- Q ASH STORAGE

FIGURE 8-4
CONCEPTUAL SITE PLAN
AMERICAN SAMOA WTE FACILITY

CHAPTER VII
CAPITAL AND OPERATING AND MAINTENANCE COST ESTIMATES

Introduction

This chapter presents the capital and operating and maintenance cost estimates for the waste-to-energy facilities that are proposed for Guam and American Samoa. Capital costs include the cost to develop the site, erect the buildings and purchase and install the equipment. Operating and maintenance costs are the costs to operate and maintain the plant. Because of the remote locations of Guam and American Samoa, transportation and labor costs will be higher than in the continental United States. Construction cost factors published by the U.S. Naval Facilities Engineering Command at Pearl Harbor, Hawaii were used to adjust continental costs for applicability in the Islands.

The cost estimates presented in this chapter will be the basis for the economic and financial analyses which will be presented and discussed in Chapter VIII. A sensitivity analysis will be conducted as part of the economic and financial analyses and will involve varying several key technical and economic variables, such as plant size, financing methods, and costs for electricity to determine the changes, if any, in the initial decision.

For purposes of this study, only the costs for the base case. i.e., a 250 tons per day (TPD), plant for Guam and a 200 TPD plant for American Samoa, will be detailed in this chapter. Capital cost estimates for various other plant sizes will be determined by computing the ratio of plant capacity, in TPD raising this ratio to the 0.8 power, and applying the resulting factor to the costs for the base case. This method is used in recognition of the economy-of-sale that occurs with larger capacity equipment. The exponent can vary from 0.4 to 1.0 depending on the type of equipment or plant, but experience has shown that for waste-to-energy power plants in this size range an exponent of 0.8 is appropriate. Thus, for various other plant sizes, only total

costs will be presented in the discussions of this chapter and in the sensitivity analysis in the next chapter.

Costs in Guam

Capital costs for the 250 TPD Guam plant are summarized in Table 7-1. The itemized list includes equipment, material, transportation, and installation labor at a continental U.S. location (California). To this subtotal, 15 percent has been added for engineering, construction management, and start-up costs, and 5 percent has been added for contingency. As shown in the table, the total cost for an installation in the continental U.S. is \$17,930,000. To adjust for the remote site, an 80 percent factor has been included bringing the total plant cost to \$32,280,00. As mentioned, the 80 percent factor is based on the geographic cost factors published by the U.S. Navy. The accuracy of this 80 percent factor should be evaluated in the preliminary engineering phase. A further discussion on this factor is presented in Chapter IX, "Viability Assessment".

Table 7-2 presents the operating and maintenance costs for the 250 TPD Guam plant. Most of the items in this table are explained by the notes. The staff level assumes the plant operates on a 24 hours per day, 7-day week basis. For power generation, utilities, and residue disposal, the plant is assumed to operate at an 85 percent capacity factor. This results in the processing of 77,600 tons of municipal solid waste ($250 \times 365 \times 0.85$) and the production of 29.23 million kwh of electricity.

Table 7-3 presents construction and operating costs as well as electrical output for a range of plant sizes on Guam. The plant sizes estimated are 150, 250, and 350 TPD operating at their capacities and a 250 TPD plant operating at 150 TPD.

TABLE 7-1
GUAM CAPITAL COST ESTIMATE
250 TPD PLANT

<u>Item</u>	<u>Installed Cost (\$1000)</u>
1. Site Development	\$570
2. Foundations	780
3. Buildings	1550
4. Scales	100
5. Cranes	600
6. Combustor/Boiler	5670
7. Fans	160
8. Boiler Feed Pumps	120
9. Cooling Pumps	70
10. Miscellaneous Pumps	50
11. Turbine-Generator	1020
12. Condenser	150
13. Miscellaneous Mechanical Equipment	200
14. Pollution Control Equipment	350
15. Stack	300
16. Large Piping	550
17. Small Piping	150
18. Ash System	500
19. Transformers	200
20. Switch Gear & MCC	150
21. Miscellaneous Elec. Equip.	500
22. Conduit, Trays, & Wiring	650
23. I&C	250
24. Mobile Equipment	100
25. Spare Parts	<u>200</u>
SUBTOTAL	\$14940
Engineering, Construction Management, Start-up (15%)	2242
Contingency (5%)	<u>748</u>
SUBTOTAL (U.S. COST)	\$17930
Remote Site Factor (80%)	<u>14350</u>
TOTAL	\$32280

TABLE 7-2
OPERATING AND MAINTENANCE COST ESTIMATE
250 TPD PLANT FOR GUAM

	<u>Annual Cost (\$1000)</u>
Plant Operation & Maintenance Staff(1)	560
Administration & Support Staff(2)	168
Parts & Supplies(3)	323
Equipment Replacement Fund(4)	162
Insurance(5)	120
Residue Disposal(6)	110
Utilities(7)	<u>239</u>
TOTAL	1682

NOTES:

- (1) 28 employees at average salary + fringe = \$20,000 each
- (2) 30% of operating and maintenance staff cost
- (3) 1% of total plant cost
- (4) 0.5% of total plant cost
- (5) 0.37% of total plant cost
- (6) Disposal cost \$6/ton (\$4 tipping + \$2 transport)
- (7) 12% of gross output at 6¢/kwh

TABLE 7-3
COST AND ELECTRICAL OUTPUT SUMMARY FOR GUAM

Plant Capacity (TPD)	150	250	350	250
Operation (TPD)	150	250	350	150
Construction Cost (\$1000) (1)	21,450	32,280	42,250	32,280
Annual Operating and Maintenance Cost (\$1000)	1,234	1,682 (2)	2,113	1,484
Annual Output (kWhx10 ⁶)	17.53	29.23	40.92	16.72
Revenue Rate (¢/kWh)	6	6	6	6

NOTES:

- (1) Includes a 1.8 multiplier over U.S. construction cost.
- (2) Operating and maintenance cost equals \$1,921,000 at electricity rate of 12¢/kwh. This cost is used in one of the cases where sensitivities of various parameters are analyzed.

Costs in American Samoa

Capital costs for the 100 TPD American Samoa plant are summarized in Table 7-4. These costs are computed the same as for Guam and the total U.S. cost for this plant is \$8,615,000. To adjust for the remote site a 100 percent factor has been included bringing the total plant cost to \$17,230,000. The accuracy of this 100 percent factor should be evaluated in the preliminary engineering phase. A further discussion on this factor is presented in Section IX, "Viability Assessment".

Table 7-5 presents the operating and maintenance costs for the 100 TPD American Samoa plant. The staff level assumes a 24 hours per day, 7-day week operation. For power generation, utilities, and residue disposal, the plant is assumed to operate at an 85 percent capacity factor. This results in the processing of 31,000 tons of municipal solid waste ($100 \times 365 \times 0.85$) and the production of 11.69 million kwh of electricity.

Table 7-6 presents construction and operating costs as well as electrical output for a range of plant sizes on American Samoa. The plant sizes estimated are 50, 100, and 150 TPD operating at full capacity and a 100 TPD plant operating at 50 TPD.

TABLE 7-4
AMERICAN SAMOA CAPITAL COST ESTIMATE
100 TPD PLANT

<u>Item</u>	<u>Installed Cost (\$1000)</u>
1. Site Development	\$275
2. Foundations	375
3. Buildings	750
4. Scales	50
5. Cranes	290
6. Combustor/Boiler	2730
7. Fans	75
8. Boiler Feed Pumps	60
9. Cooling Pumps	30
10. Miscellaneous Pumps	25
11. Turbine-Generator	490
12. Condenser	70
13. Miscellaneous Mechanical Equipment	95
14. Pollution Control Equipment	170
15. Stack	145
16. Large Piping	260
17. Small Piping	70
18. Ash System	240
19. Transformers	95
20. Switch Gear & MCC	70
21. Miscellaneous Elec. Equipment	240
22. Conduit, Trays, & Wiring	310
23. I&C	120
24. Mobile Equipment	50
25. Spare Parts	<u>95</u>
SUBTOTAL	\$7180
Engineering, Construction Management, Start-up (15%)	1076
Contingency (5%)	<u>359</u>
SUBTOTAL (U.S. Cost)	\$8615
Remote Site Factor (100%)	<u>8615</u>
TOTAL	\$17230

TABLE 7-5
OPERATING AND MAINTENANCE COST ESTIMATE
100 TPD PLANT FOR AMERICAN SAMOA

	<u>Annual Cost (\$1000)</u>
Plant Operation & Maintenance Staff(1)	\$420
Administration & Support Staff(2)	126
Parts & Supplies(3)	172
Equipment Replacement Fund(4)	86
Insurance(5)	64
Residue Disposal(6)	29
Utilities(7)	<u>287</u>
Total	\$1184

NOTES:

- (1) 21 employees at average salary + fringe = \$20,000 each
- (2) 30% of operating and maintenance staff cost
- (3) 1% of total plant cost
- (4) 0.5% of total plant cost
- (5) 0.37% of total plant cost
- (6) Disposal cost \$4/ton (\$2 tipping + \$2 transport)
- (7) 12% of gross output at 19¢/kwh

TABLE 7-6
COST AND ELECTRICAL OUTPUT
SUMMARY FOR AMERICAN SAMOA

Plant Capacity (TPD)	50	100	150	100
Operation (TPD)	50	100	150	50
Const. Cost (\$1000) (1)	9,900	17,230	23,830	17,230
Annual Operating and Maintenance Cost (\$1000)	812	1,184 (2)	1,543	1,023
Annual Output (kWhx10 ⁶)	5.85	11.69	17.53	5.17
Revenue Rate (¢/kWh)	15	15	15	15

NOTES:

- (1) Includes a 2.0 multiplier over U.S. construction costs
- (2) Operating and maintenance cost equals \$1,455,000 at electricity rate of 35¢/kwh. This cost is used in one of the cases where sensitivities of various parameters are analyzed.

CHAPTER VIII
ECONOMIC AND FINANCIAL ANALYSIS

General

The primary objective in this study is to evaluate the feasibility of energy recovery through combustion of municipal solid waste (MSW) in Guam and American Samoa. This evaluation will provide guidance for future decisions regarding the development of waste-to-energy facilities in these island locations. The feasibility of pursuing similar projects in other Pacific Islands is also assessed on a preliminary basis.

One aspect of the feasibility assessment relates to the technical viability of waste-to-energy systems. The preceding chapters have addressed this aspect of the feasibility study particularly Chapter V, "Technology Review" and Chapter VI, "Appropriate Technology". At this point, the focus of the report shifts to the economic analyses, including methods of financing the projects. Hence, the overall feasibility of the projects can be determined. The summary assessment of the viability of the proposed waste-to-energy projects will be presented in the next chapter.

To evaluate the feasibility of waste-to-energy conversion projects in Guam and American Samoa, key economic and technical variables were identified for analysis. These variables included:

- o Plant capacity;
- o Methods of financing;
- o Capital costs;
- o Operations and maintenance costs;
- o Cost of electricity i.e., revenues; and
- o Waste quantity

The method of analysis utilized in the study is commonly referred to as a "sensitivity analysis". This method essentially involves initially selecting a particular base set of values for each of the

variables and assessing the economic feasibility of the project. Subsequently, variations in the values of the variables are introduced, on a variable-by-variable basis, while holding the rest constant. With each new scenario, the resulting economic decision is determined and compared with the base scenario. Through successive iterations, not only can the projects' feasibility be determined for particular scenarios, but, more importantly, the sensitivity of the decision to changes in economic and technical conditions can be assessed.

Sensitivity analyses are useful particularly where changes in the economic and/or technical conditions are expected to occur. However, the method can quickly become cumbersome depending on the number of variables under consideration. Use of computers can facilitate such analyses and can allow evaluation of numerous scenarios.

A computerized analysis was conducted in this study due to the number of variables and scenarios that were considered. Table 8-1 lists the key economic and technical variables for each case scenario evaluated for Guam and American Samoa. It can be seen that, with the exception of methods of financing, all the variables have been presented and discussed in this report up to this point. It is appropriate then to discuss at this time the various alternatives for financing the waste-to-energy projects that are envisioned for Guam and American Samoa.

Alternative Project Financial Structures

The methods and organizational structures used to finance the waste-to-energy projects must enhance the operational and economic performance of the project. Consequently, these structures must allow for a rational distribution of risks, responsibilities, and rewards to the various participants in the projects. They must also facilitate the use of low cost financing and the utilization of available tax benefits. Three main alternative structures appear to be available for waste-to-energy projects, as follows:

TABLE 8-1

ECONOMIC AND TECHNICAL VIABILITY VARIABLES

<u>CASE</u>	<u>PLANT (1) CAPACITY (TPD)</u>	<u>METHOD (2,3) OF FINANCING</u>	<u>CAPITAL COSTS</u>	<u>O & M COSTS</u>	<u>ELECTRICITY COST (REVENUE) (¢/kwh)</u>	<u>WASTE QUANTITY (TPD)</u>
<u>GOVERNMENT OF GUAM</u>						
1	250	Private	Base	Base	6	250
2	350	Private	Base	Base	6	350
3	150	Private	Base	Base	6	150
4	250	Private	Base	B + 25%	6	250
5	250	Private	Base	B - 25%	6	250
6	250	Public	Base	Base	6	250
7	250	Private	B + 25%	Base	6	250
8	250	Private	B - 25%	Base	6	250
9	250	Private	Base	Base	6	150
10	250	Private	Base	Base	12	250
11	250	Grant	Grant	Base	6	250
<u>AMERICAN SAMOA GOVERNMENT</u>						
1	100	Public	Base	Base	15	100
2	150	Public	Base	Base	15	150
3	50	Public	Base	Base	15	50
4	100	Public	Base	B + 25%	15	100
5	100	Public	Base	B - 25%	15	100
6	100	Private	Base	Base	15	100
7	100	Public	Base	Base	15	50
8	100	Public	Base	Base	35	100
9	100	Grant	Grant	Base	15	100

Notes:

- (1) Base case for Guam and American Samoa is 250 tons per day (TPD) and 100 TPD, respectively.
- (2) Public financing is through tax exempt bond at an interest rate of 10 percent for a 20 year term. Private financing is through a 30 percent equity/70 percent industrial revenue bond at an interest of 10 percent for a 20 year term. Grant financing is through a 100 percent grant.
- (3) It is assumed that the government will own the waste-to-energy facility for the public option and a private entity will own the facility for the private financing option. No tax credits, investment tax credits (ITC) and energy tax credits (ETC) are utilized in the private financing option.
- (3) The following factors will be utilized in the evaluation:
 - a. Escalation of electricity - 7 percent
 - b. General inflation - 5 percent
 - c. Interest used on invested funds - 10 percent
 - d. Debt coverage factor - 1.25
 - e. Financing and all other related fees - 5 percent of required capital
 - f. Cost for landfill disposal
 - Guam - \$4.00 per ton
 - American Samoa - \$2.00 per ton

- o Public ownership by the Island Governments - The Government of Guam and the American Samoa Government would have complete control of and responsibility for all aspects of the project. The project could be financed using either municipal revenue bonds, certificates of participation in a lease transaction, or general obligation bonds.
- o Private ownership with private financing - A private party would have full responsibility for the project and the involvement of each island government would be limited to a contractual commitment to deliver MSW to the plant. The project could be financed partly with investor equity and partly with medium term (10-15 year) bank debt. In addition to the standard 10 percent investment tax credit, about 75 percent of the project capital costs would be eligible for a 10 percent energy tax credit. For tax purposes, project property would be eligible for a five-year accelerated depreciation; the depreciation base would be reduced by 50 percent of the value of the investment and energy tax credits.
- o Private ownership with Industrial Revenue Bond (IRB) financing - A private party would retain full responsibility for the project. However, since the governments of each island would participate in the issuance of the IRB's (on the basis of the private party financial backing) the governments would be able to influence some aspects of project development and perhaps negotiate an advantageous waste disposal agreement. The bonds could be issued by the island government or by an allied agency. The investment tax credit and depreciation treatment of the project would be the same as for a privately financed project. However, the maximum energy tax credit available would be 5 percent, which could be reduced proportionately to the share of tax-exempt IRB's in the overall project financing. The economic impact of the reduction in the energy tax credit could be more than offset by the relatively

low interest rates and long terms (20-25 years) available for IRB financings.

It is of interest to discuss the interaction of the various parties under the various project structures described above. This discussion follows.

If revenue bonds are used to finance the projects, the financing relationships among the parties are quite simple:

- o The government (or an associated agency) issues bonds backed solely by the project revenue or by the credit of the government; interest on these bonds is exempt from federal taxes.
- o Lenders purchase the revenue bonds and the government receives the proceeds.

Project structures for the two private-ownership options would take the following forms. If both project ownership and financing are fully private, the required project structure is very simple:

- o The private project owner provides some fraction of total project costs as equity and raises the remainder as debt issued by lenders such as banks. To raise such debt financing, the project owner may guarantee debt repayment, providing security from its other assets, or it may pledge its ownership in the project as the sole debt security. This latter approach is, however, viable only for economically strong projects.
- o Equity and debt funds are commonly held by the project owner and used to pay the overall project contractor (a turnkey approach is again assumed) and the owner takes title to the project facilities.

If a private owner were to use IRB financing for the project, the transactions involved during the construction period would be as follows:

- o The governments of each island (or a similar agency) issues IRB's for all or part of the project costs. Interest on these bonds is exempt from federal income taxes.
- o The private project owner guarantees debt service on these bonds, either from project revenues, if these are sufficiently strong, or from its other resources.
- o The project owner uses the proceeds from the IRB's, probably in combination with some equity funds, to finance the engineering and construction of the project by a turnkey contractor and takes title to the project facilities upon completion.

Once the plants commence operations, the relationships among the various parties are much the same regardless of the approach used for financing the project. These relationships are illustrated as follows:

- o The project owner, or lessee, receives income from the provision of waste disposal services to the island and from the sale of electricity and/or steam.
- o Out of these revenues, the owner/lessee pays its operating costs. The plant can be operated either by the owner/lessee or by another party under contract.
- o After covering plant operating costs, the owner/lessee pays debt service charges or lease installments due and retains any remaining revenue as return on its investment.

Economic Analysis

As mentioned at the outset of this chapter, a computer program was used to perform the economic analysis for the Guam and American Samoa waste-to-energy facilities. The output of the economic analysis program (see Appendix B) consists of two sections. The upper section presents an annual cash flow analysis and net present value analysis. The bottom section presents assumptions used in constructing these analyses. The computer program utilized for the analysis was written so that all assumptions regarding costs, interest rates, inflation rates, etc. could be entered directly into an "assumptions menu". Changes in the assumptions could then be analyzed for impacts upon the other economic variables or factors. For example, the change in the interest rate on debt would cause necessary changes in debt service and other calculations in the model.

The various assumptions and definitions of terms utilized in the economic analysis as well as costs that are calculated are briefly described as follows:

Plant Capacity - the design capacity of the facility, expressed in tons per day (TPD).

Operation - the expected waste throughput of the facility, expressed in tons per day (TPD).

Construction Cost - the estimated construction cost of the facility in 1984 dollars, i.e., year zero.

Annual Output - the estimated kilowatt hour (kwh) output.

Revenue Rate Electricity - electrical price in 1984 dollars.

Financing Fees - fees calculated as a percentage of the construction cost to be financed.

Equity Contribution - equity investment, entered as a percentage of construction cost.

Total Required Capital - the sum of the equity and financed funds.

Required Debt Coverage Factor - a factor calculated by multiplying debt service by the applied factor.

Term - the term of financing in years.

Operation Cost - cost of operating the facility in year zero, includes labor and materials.

Maintenance Cost - cost of maintenance, labor and materials in year zero.

Tipping Fee - cost of disposing the municipal solid waste at the waste-to-energy facility, expressed in dollars per ton of waste.

Insurance Cost - cost of insurance in year zero.

Residue Disposal Cost - cost of disposing of residue at local landfill in year zero.

Landfill Cost - total dollar cost of landfill operation in year zero.

Discount Factor - interest rate at which life cycle costs are discounted to year zero.

Electricity Escalation Factor - annual rate of increase in electricity prices.

Operation and Maintenance Escalation Factor - annual rate of increase of operation and maintenance cost.

Landfill Escalation Factor - annual rate of increase in landfill cost.

Cost of Borrowed Funds - interest rate on debt.

Maintenance Fund - initial fund to cover maintenance (escalates at the same rate as O&M).

Landfill Tip Fee - cost of landfill in dollars per ton in year zero.

Life cycle analyses were performed for various scenarios for Guam and American Samoa in which the five following parameters were varied:

- o Plant capacity
- o Capital cost
- o O&M costs
- o Electricity costs
- o Financing

In addition, a life cycle cost of the current landfilling practice in each island was developed for comparison with the resource recovery options. Net present values of all options were calculated as shown in the output tables in Appendix B. The net present value of an option may be interpreted as the cost or savings of that option over the project life expressed in zero year dollars.

Economic Analysis for Guam

The results of the economic analysis for Guam are summarized in a series of figures which show tipping fee versus time for the various conditions taken into consideration. A discussion of these

conditions and their impacts on tipping fees versus time follows:

Plant Capacity - On Figure 8-1, four resource recovery cases are compared. From the results, it is clear that tipping fee is sensitive to plant capacity, i.e., at 350 TPD, the first year tipping fee is \$38/ton while at 150 TPD the tipping fee increases to \$53/ton. Note that a facility designed for 250 TPD but with actual throughput of 150 TPD results in a tipping fee of \$85/ton first year. Until year nineteen, landfill life cycle costs are well below the best resource recovery case (350 TPD on this graph).

Capital Costs- On Figure 8-2, four resource recovery cases are compared. As expected, capital cost effects the tipping fee, i.e., at the base case plus 25 percent the first year tipping fee is \$55/ton while at the base case less 25 percent the tipping fee is \$32/ton. The best case if zero capital cost, grant option, with first year tipping fee of minus \$2/ton. The grant option is more favorable than the landfill case.

O&M Costs - On Figure 8-3, three resource recovery cases are compared. The tipping fee is found to be sensitive to O&M costs, i.e., at the base case plus 25 percent, the first year tipping fee is \$49/ton while at the base case less 25 percent the first year tipping fee is \$38/ton.

Electricity Costs- On Figure 8-4, two resource recovery cases are compared. Tipping fee is found to be very sensitive to revenue rate. First year tipping fee at \$0.06/kwh is \$43/ton compared with first year tipping fee of \$23/ton at \$0.12/kwh. At an electricity cost of \$0.12/kwh, the resource recovery life cycle cost equals landfill costs at year seven and are lower than landfill costs thereafter.

Financing - On Figure 8-5, three resource recovery cases are compared. Again, the grant proved to be the most desirable

CONDITIONS

FINANCING: PRIVATE

CAPITAL COST: BASE

O & M: BASE

ELECTRICITY COST: \$0.06/kwh

GUAM CASES 1, 2, 3, and 9

SEE TABLE 8-1

FIGURE 8-1

**TIPPING FEES VS. TIME
GUAM WTE FACILITY
VARIABLE: PLANT CAPACITY**

CONDITIONS

FINANCING: PRIVATE/GRANT

O & M COST: BASE

ELECTRICITY COST: \$0.06/kwh

PLANT CAPACITY: 250 TPD

WASTE QUANTITY: 250 TPD

GUAM CASES 1, 6, 7, and 11
SEE TABLE 8-1

FIGURE 8-2
TIPPING FEES VS. TIME
GUAM WTE FACILITY
VARIABLE: CAPITAL COSTS

way to finance the project. Private financing with equity participation proved to be more cost effective than public financing. No tax credits including investment tax credits (ITC) and energy tax credits (ETC) were considered in the private financing option.

In order to make an economic comparison of the eleven case scenarios, a present worth analysis was performed. The results of this analysis are included in Appendix B and are summarized in Table 8-2.

As a result of the sensitivity analysis investigating the implementation of resource recovery on Guam, the following conclusions may be drawn:

- o Tipping fees are most sensitive to revenue rate;
- o Tipping fees are equally sensitive to capital costs and operation and maintenance costs;
- o Private financing with equity participation results in a lower tipping fee than public financing;
- o Tipping fees are moderately sensitive to plant design capacity; however, if the waste quantities actually received are substantially less than expected in the original design, the tipping fees increase substantially;
- o Grant funding for the resource recovery project would result in lower tipping fees than landfill; and
- o Except for the grant funding case, landfill is the lowest cost waste disposal alternative for Guam.

Economic Analysis for American Samoa

The results of the economic analysis for American Samoa are also summarized in a series of figures which show the tipping fees over time for the various conditions taken into consideration. The

TABLE 8-2
NET PRESENT VALUES
FOR GUAM WTE FACILITY

<u>Case (1)</u>	<u>VARIABLE CHANGED</u>	NET PRESENT ⁽³⁾ VALUE (\$1,000)
1	None - Base Case (2)	- 34,604
2	Plant Capacity: 350 TPD	- 39,777
3	Plant Capacity: 150 TPD	- 27,927
4	O&M Cost: Base case plus 25%	- 43,007
5	O&M Cost: Base case less 25%	- 27,412
6	Financing: Public	- 53,761
7	Capital Cost: Base case plus 25%	- 45,838
8	Capital Cost: Base case less 25%	- 23,370
9	Waste Quantity: 150 TPD	- 48,903
10	Electricity Cost: \$0.12/kwh	3,240
11	Capital Cost: Grant	10,332

NOTES:

(1) See Table 8-1 for further description of case variables.

(2) Base Case Conditions:

- a) Plant Capacity: 250 TPD
- b) Financing: Private
- c) Capital Cost: Base (\$32,280,000)
- d) O&M Cost: Base (\$1,055,000/year)
- e) Electricity Cost: \$0.06/kwh
- f) Waste Quantity: 250 TPD

(3) See Appendix B

CONDITIONS

FINANCING: PRIVATE
 CAPITAL COST: BASE
 ELECTRICITY COST: \$0.06/kwh
 PLANT CAPACITY: 250 TPD
 WASTE QUANTITY: 250 TPD
 GUAM CASES 1, 4, and 5
 SEE TABLE 8-1

8-15

FIGURE 8-3
TIPPING FEES VS. TIME
GUAM WTE FACILITY
VARIABLE: O & M COSTS

CONDITIONS

TIME (YEARS)

FINANCING: PRIVATE
 CAPITAL COST: BASE
 O & M COST: BASE
 PLANT CAPACITY: 250 TPD
 WASTE QUANTITY: 250 TPD
 GUAM CASES 1 and 10
 SEE TABLE 8-1

8-16

FIGURE 8-4
 TIPPING FEES VS. TIME
 GUAM WTE FACILITY
 VARIABLE: ELECTRICITY COSTS

CONDITIONS

CAPITAL COST: BASE

O & M COST: BASE

ELECTRICITY COST: \$0.06/kwh

PLANT CAPACITY: 250 TPD

WASTE QUANTITY: 250 TPD

GUAM CASES 1, 6, and 11

SEE TABLE 8-1

FIGURE 8-5

TIPPING FEES VS. TIME
GUAM WTE FACILITY
VARIABLE: FINANCING METHOD

impacts of these conditions on tipping fees are discussed as follows:

Plant Capacity - On Figure 8-6, four resource recovery cases were compared. From the results, it is clear that tipping fee is sensitive to plant capacity, i.e., at 150 TPD first year tipping fee is \$54 per ton while at 50 TPD the tipping fee increases to \$92 per ton. Note that a facility designed for 100 TPD but with actual throughput of 50 TPD results in a tipping fee of \$186/ton first year. Until year thirteen landfill life cycle costs are well below the best resource recovery case on this graph, i.e., 150 TPD.

Capital Costs - On Figure 8-7, two resource recovery cases were compared. The best case is zero capital cost, grant option, with first year tipping fee of minus \$21/ton. The grant option is more favorable than the landfill case.

O&M Costs - On Figure 8-8, three resource recovery cases are compared. Tipping fee is found to be sensitive to O&M costs, i.e., at the base cost plus 25 percent first year tipping fee is \$74/ton while at the base less 25 percent first year tipping fee is \$57/ton.

Electricity Costs - On Figure 8-9 two resource recovery cases are compared. Tipping fee is found to be very sensitive to revenue rate. First year tipping fee at \$0.12/kwh is \$65/ton compared with first year tipping fee of minus \$5/ton at \$0.35/kwh. For this analysis, resource recovery is a more cost effective option than landfill.

Financing - On Figure 8-10, three resource recovery cases are compared. Again the zero capital, grant option, proved to be the most desirable way to finance the project. Private financing with equity participation proved to be more cost effective than public financing. No tax credits, including

CONDITIONS

FINANCING: PRIVATE

CAPITAL COST: BASE

O & M COST: BASE

ELECTRICITY COST: \$0.15/kwh

**AMERICAN SAMOA CASES 1, 2, 3, and 7
SEE TABLE 8-1**

FIGURE 8-6

**TIPPING FEES VS. TIME
AMERICAN SAMOA WTE FACILITY
VARIABLE: PLANT CAPACITY**

CONDITIONS

FINANCING: PUBLIC/GRANT

O & M COST: BASE

ELECTRICITY COST: \$0.15/kwh

PLANT CAPACITY: 100 TPD

WASTE QUANTITY: 100 TPD

AMERICAN SAMOA CASES 1 and 9

SEE TABLE 8-1

TIME (YEARS)

FIGURE 8-7

**TIPPING FEES VS. TIME
AMERICAN SAMOA WTE FACILITY
VARIABLE: CAPITAL COST**

CONDITIONS

FINANCING: PUBLIC

CAPITAL COST: BASE

ELECTRICITY COST: \$0.15/kwh

PLANT CAPACITY: 100 TPD

WASTE QUANTITY: 100 TPD

AMERICAN SAMOA CASES 1, 4, and 5
SEE TABLE 8-1

FIGURE 8-8

TIPPING FEES VS. TIME
AMERICAN SAMOA WTE FACILITY
VARIABLE: O & M COSTS

investment tax credits (ITC) and energy tax credits (ETC) were considered in the private financing option.

As completed in the analyses for Guam, a present worth analysis was performed for the nine cases evaluated for American Samoa, the present worth values for each case scenario are presented in Table 8-3.

As a result of the sensitivity analysis investigating the implementation of a resource recovery plant in American Samoa, the following conclusions can be drawn:

- o Tipping fees are most sensitive to revenue rate;
- o Tipping fees are moderately sensitive to O&M costs and plant capacity; however, if a facility received significantly less waste quantities than expected in the original design, the tipping fee increases substantially;
- o Grant funding for the resource recovery project would result in lower tipping fees than landfill; and
- o Except for the grant funding case, landfill is the lowest cost waste disposal alternative for American Samoa.

TABLE 8-3
NET PRESENT VALUES
FOR AMERICAN SAMOA WTE FACILITY

<u>Case</u>	<u>(1)</u>	<u>VARIABLE CHANGED</u>	NET PRESENT ⁽³⁾ VALUE <u>(\$1,000)</u>
1		None - Base Case ⁽²⁾	- 14,515
2		Plant Capacity: 150 TPD	- 13,374
3		Plant Capacity: 50 TPD	- 13,959
4		O&M Cost: Base case plus 25%	- 19,705
5		O&M Cost: Base case less 25%	- 9,329
6		Financing: Private	- 4,326
7		Waste Quantity: 50 TPD	- 34,981
8		Electricity Cost: \$0.35/kwh	36,567
9		Capital Cost: Grant	19,750

NOTES:

(1) See Table 8-1 for further description of case variables.

(2) Base Case Conditions:

- a) Plant Capacity: 100 TPD
- b) Financing: Private
- c) Capital Cost: Base (\$17,230,000)
- d) O&M Cost: Base (\$864,000/year)
- e) Electricity cost: \$0.15/kwh
- f) Waste Quantity: 100 TPD

(3) See Appendix B

CONDITIONS

FINANCING: PUBLIC

CAPITAL COST: BASE

O & M COST: BASE

PLANT CAPACITY: 100 TPD

WASTE QUANTITY: 100 TPD

AMERICAN SAMOA CASES 1 and 8

SEE TABLE 8-1

FIGURE 8-9

**TIPPING FEES VS. TIME
AMERICAN SAMOA WTE FACILITY
VARIABLE: ELECTRICITY COSTS**

CONDITIONS

CAPITAL COST: BASE

O & M COST: BASE

ELECTRICITY COST: \$0.15/kwh

PLANT CAPACITY: 100 TPD

WASTE QUANTITY: 100 TPD

AMERICAN SAMOA CASES 1, 6, and 9

SEE TABLE 8-1

TIME (YEARS)

FIGURE 8-10

TIPPING FEES VS. TIME
AMERICAN SAMOA WTE FACILITY
VARIABLE: FINANCING METHOD

CHAPTER IX
VIABILITY ASSESSMENT

General

The conversion of municipal solid waste to energy in a waste-to-energy plant has been used in many locations and can be accomplished in an environmentally acceptable manner. This study confirms that waste-to-energy plants could be built in the Pacific Islands to convert MSW to energy in an environmentally safe manner. As with many waste-to-energy projects, the economics may not appear favorable with small size units, particularly if low-cost landfill is an alternative. Another factor affecting the economics of the facilities evaluated for Guam and American Samoa is the high plant construction costs that were assumed because of their remote locations. For these plants to be economical some form of governmental assistance such as instituting MSW collection fees or a construction grant may be needed. There is also the possibility of substantially reducing capital costs by employing different procurement and financing methods other than those assumed for this study.

Viability in Guam

From a technical and environmental viewpoint, a MSW waste-to-energy plant in Guam is viable. A good site is available near the existing Cabras Island and Piti Power Plants. This site was assumed for the plot plan presented on Figure 6-3. The Guam waste-to-energy plant, as evaluated, would produce only electricity since there are no nearby thermal loads to be served. Design measures include the control of air emissions, wastewater, and ash disposal to protect the environment.

The major concern with project viability in Guam is the economics. As indicated in Chapter VIII, "Economic and Financial Analysis", the only cases that show an improvement in net present value over landfill are those in which electricity is purchased from the WTE facility at \$0.12/kwh (Case 10, Table 8-1) and in which a 100 percent grant for construction costs is obtained (Case 11, Table

8-1). The grant case results in a considerable improvement over landfill.

Because the economic analysis hinges on the various cost estimates and assumptions that were made, an improved economic outlook for a waste-to-energy facility on Guam would result if these estimates and assumptions could be improved. Several areas for improvement appear worthwhile to pursue.

First, it should be noted that the construction cost estimates used for the analysis were based on U.S. Navy experience for general construction on Guam. These costs, which are generally 80 percent more than those expected to prevail in California, assume extensive use of materials made in the United States, high shipping costs and prevailing U.S. construction wages. A substantial savings could be achieved by use of equipment, material and labor from less expensive sources, e.g., the Far East. Areas to be explored in this regard could include solicitation of bids from turnkey contractors. Through competitive procurement procedures it may be possible to reduce the capital construction costs indicated in this study by as much as fifty percent. For the private financing option, that could utilize energy tax credits and investment tax credits, the cash flow situation can improve considerably.

Additional savings in capital construction costs may result if the waste-to-energy plant were integrated with one of the existing oil-fired power plants at Cabras Island or Piti. Such an integration would save the cost of the turbine-generator, condenser, cooling system and a considerable portion of the electrical, instrumentation and control systems. However, as has been pointed out, integration of oil-fired steam cycles with waste-to-energy plant steam cycles is not a simple matter. The actual savings in capital costs needs to be clearly established through a more detailed

engineering investigation if this avenue of capital cost savings is to be pursued.

Finally, the economic outlook for a waste-to-energy facility on Guam would be considerably improved by increasing revenue for the facility. Higher tipping fees could be compensated by instituting a household charge for garbage collection. As an example, if a \$4.00 fee was assessed for garbage collection from approximately 20,000 households, a monthly revenue of \$80,000 would be obtained, accounting for over fifty percent of the anticipated monthly O&M costs for the facility.

It should be noted that the Ordot Landfill will require substantial improvement over the next few years. As indicated in the Guam Solid Waste Management Plan, capital improvements are needed at this time to improve the operation of the landfill and to extend its useful life for fifteen more years. The cost of these improvements are estimated to be approximately \$1.2 million (1984 costs).

In summary, based on the preliminary analysis completed during this study, a 250 ton per day MSW waste-to-energy facility on Guam appears to be technically, environmentally and economically feasible under certain conditions. The facility, as discussed, could be financed in a number of different ways.

If the project were to be implemented using private financing methods, the preliminary analysis indicates that some combination of the following conditions would be necessary.

- a) The revenue from electricity produced would need to be higher than \$0.06/kwh and may need to approach the electricity costs passed on to the consumer, i.e., approximately \$0.12/kwh;
- b) The capital costs for construction of the facility would be substantially reduced through competitive procurement of equipment, materials and labor (e.g. the Far East);

- c) The waste-to-energy facility would be designed to produce steam that could be integrated with the existing power plant at Cabras Island; and/or
- d) Fees would be instituted for the collection of garbage to assist in off-setting higher tipping fees.

If the project were to be implemented using public financing methods, the preliminary analysis indicates that not only would some combination of the above four conditions be necessary, but it also appears that a substantial portion of the capital cost obligation would have to be met through a construction grant or other type of government subsidy. As an example, for the base case (Case 1, Table 8-1), a 62 percent construction grant would be sufficient to reach the break even point, i.e., the net present value for the waste-to-energy facility would be equal to the present worth value of the annual landfill costs.

Viability in American Samoa

From a technical and environmental viewpoint, a MSW waste-to-energy plant in American Samoa is viable. A good site is available near the existing diesel-fueled Tafuna Power Plant, as was assumed for the plot plan presented on Figure 6-4. The American Samoa plant would produce only electricity since there are no nearby thermal loads to be served at this time. Design measures include the control of air emissions, wastewater, and ash disposal to protect the environment.

As with Guam, the major concern with viability in American Samoa is economics. In Chapter VIII, "Economic and Financial Analysis", the only cases that result in an improvement in net present value over landfill are the case in which electrical power costs \$0.35/kwh and the case in which a 100 percent grant for construction cost is obtained. The grant case represents a considerable improvement over landfill.

As with Guam, several areas should be explored to improve upon the basis for the economic analysis. The construction cost was based on U.S. Navy experience for general construction in American Samoa (100 percent more than California) and may overestimate the cost for the same reasons stated for Guam. As with Guam, savings may result from the use of material and labor from the Far East. Contrary to Guam, the possibility of integration with an existing utility plant does not exist since American Samoa does not have any steam plants for electrical generation. As with Guam, however, the economic outlook could be improved by higher tipping fees to cover the cost of improved landfill operation or income from a household charge for garbage collection. Either of these measures would result in considerably improved economics.

The Futiga Landfill will require some improvement in the near future. According to ASG's Solid Waste Management Plan, the present landfill site can be improved to extend its useful life to fifteen more years.

In summary, a MSW waste-to-energy plant is technically and environmentally viable on American Samoa but is marginal from an economic standpoint, based on the assumptions used in this study. In order for a MSW waste-to-energy facility to be financially feasible in American Samoa it appears that a construction grant or other type of government subsidy would have to be provided to finance the capital cost of the facility. It should be noted however, that this study did not assess the feasibility of utilizing other renewable resources for energy resource recovery. As indicated earlier, the use of woody biomass materials may be feasible in combination with MSW energy recovery facilities. The feasibility of this type of facility would require further evaluation of location and availability of biomass materials; collection, shipment and reforestation costs; heating and moisture values of the biomass material, etc. Because of the larger plant capacity that could be developed if biomass was incorporated into the waste-to-energy facility, the economic outlook for the facility

is improved due to economies of scale. However, it is likely that a substantial grant would be required to assist in financing the construction costs in any event. As an example, for the base case, (Case 17, Table-1) a 38 percent construction grant would be sufficient to reach the break even point i.e., the net present value for the waste-to-energy facility is equal to the present worth value of landfill costs.

Viability in the Pacific Islands

Based on the assessments of the viability of waste-to-energy facilities on Guam and on Tutuila Island in American Samoa, it may be reasonably concluded that waste-to-energy facilities are presently not viable in the Commonwealth of the Northern Mariana Islands, the Republic of Palau, the Federated States of Micronesia, the Republic of the Marshall Islands and in the outer islands of American Samoa. This conclusion is based on the following factors:

- o The quantities of MSW generated in these Islands are considerably less than on Guam or Tutuila Island, American Samoa due to smaller population bases and significantly less per capita MSW rates, as indicated in Chapter IV.
- o Compositionally, the MSW in these islands is characterized by a higher percentage of metal wastes. Thus, the recoverable energy content of the MSW would be less than on Guam or American Samoa.
- o Notwithstanding the technological constraints represented in the two factors discussed above, costs for construction as well as operation and maintenance of facilities in these islands have historically been higher than on Guam or American Samoa due to the relatively remote locations of the islands as well as the lack of infrastructure, skilled labor, etc. Moreover, the islands (with the possible exception of Saipan) lack a concentrated population base resulting in more costly collection of the MSW.

In summary, despite the technical feasibility of waste-to-energy facilities on Guam and American Samoa such facilities are marginally economical for Guam and American Samoa under the conditions established in this study. The technological constraints and the higher costs that are normally encountered in the Northern Marianas, Palau, the Federated States of Micronesia and the Marshalls, make it highly unlikely that waste-to-energy facilities would be economically feasible within these other Pacific Islands.

CHAPTER X

IMPLEMENTATION STRATEGY

General

A waste-to-energy project generally proceeds through the five phases listed in Table 10-1. This study has encompassed Phase I, Initial Planning, with some elements of Phase II, Detailed Planning, included. The results of this study indicate that further effort is required to refine the basis for the economic analysis. In essence then, a more detailed feasibility analysis should be undertaken since the Waste-To-Energy facilities for Guam and American Samoa are technically and environmentally viable but only marginally economical. Therefore, in the context of the phased development of Waste-To-Energy projects as illustrated by Table 10-1, the two projects may be appropriately considered at the Phase II, Detailed Planning stage.

With respect to the overall strategy for pursuing the Waste-To-Energy facilities for Guam and American Samoa, the following sections focus on the detailed planning activities that should be pursued next. Upon completion of these detailed planning activities, the economic analysis should be rerun on the basis of refined estimates for construction costs and revenues. If the economic analysis indicates that the projects are economically feasible, detailed designs, construction and operation may then be pursued. Figure 10-1 presents a preliminary time schedule for implementation of the project(s).

Guam

Because the economic outlook for the WTE facility on Guam is marginal under the conditions analyzed in this study but may be feasible under certain conditions of financing, revenue and costs, the activities that should be of immediate concern include:

1. Construction costs should be investigated more closely to determine if inexpensive sources for materials and

TABLE 10-1
PHASES OF A WASTE-TO-ENERGY PROJECT

PHASE I: INITIAL PLANNING

- Problem Formulation	- Potential Sites
- Potential Solutions	- Conceptual Feasibility
- Potential Products and Markets	- Major Issues

PHASE II: DETAILED PLANNING

- Site Selection	- Preliminary Engineering
- Waste Procurement	- Detailed Feasibility
- Energy Price	- Procurement Approach
- Financing Terms	- Implementation Plan
- Integration with Existing Power Plant	

PHASE III: IMPLEMENTATION

- Draft EIR	- Final Financing and Energy Sales
- Permits	- Detailed Design and Specifications

PHASE IV: CONSTRUCTION

- Construction Management	- Construction
- Equipment Procurement	- Start Up and Shakedown

PHASE V: OPERATION

- Operation and Maintenance	- Administration

FIGURE 10-1

WASTE-TO-ENERGY PLANT
PROJECT SCHEDULE

labor in the Far East can be utilized. One possible means of accomplishing this is to solicit estimates from turnkey contractors.

2. The possibility of integrating Waste-To-Energy facilities with existing oil-fired power plants should be explored as a means of reducing capital investment.
3. The possibilities of increasing revenue should be explored particularly with respect to garbage collection fees.
4. The quantities and composition of MSW on Guam should be confirmed through more detailed field surveys and compositional analysis.
5. The costs at which electricity would be purchased from the proposed Waste-To-Energy facility should be confirmed through discussions with the Guam Power Authority. Ideally, some commitment should be obtained, such as a letter of intent.
6. The financing and ownership issues should be resolved not only to determine if public or private financing will be available but to determine the terms of the financing.

American Samoa

Because the economic outlook for the Waste-To-Energy facility on Tutuila Island in American Samoa hinges to a great extent on grant funding for the project, the most immediate concern is the pursuit of such funding. Without grant funding the project is only technically and environmentally feasible but not economically feasible.

If grant funding for the Waste-To-Energy facility can be obtained, other secondary detailed planning activities may then be pursued.

These activities would be similar to Guam's case with one exception: the integration of the proposed Waste-To-Energy facility with an existing power plant. This technical alternative is not possible on American Samoa because the existing plants utilize diesel-powered generators.

APPENDIX A
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APPENDIX A
BIBLIOGRAPHY

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APPENDIX B
COMPUTERIZED PRINTOUTS OF ECONOMIC ANALYSIS

GUAM RESOURCE RECOVERY CASH FLOW CASE 1 GUAMCI

YEAR	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
REVENUE																					
PMR ELECT	2148	2299	2460	2632	2816	3013	3224	3450	3691	3950	4226	4522	4839	5177	5540	5928	6342	6786	7261	7770	8314
SUBTOTAL	2148	2299	2460	2632	2816	3013	3224	3450	3691	3950	4226	4522	4839	5177	5540	5928	6342	6786	7261	7770	8314
EXPENSE																					
DEBT SERVICE	4147	4147	4147	4147	4147	4147	4147	4147	4147	4147	4147	4147	4147	4147	4147	4147	4147	4147	4147	4147	4147
OPERATION	1221	1282	1346	1413	1484	1558	1636	1718	1803	1894	1988	2088	2192	2302	2417	2538	2664	2798	2938	3084	3239
MAINT	272	285	300	315	330	347	364	383	402	422	443	465	488	513	538	565	594	623	654	687	721
INSUR	139	146	153	161	169	177	186	195	205	215	226	237	249	262	275	289	303	318	334	351	368
RESID DISP	127	134	140	147	155	162	171	179	188	197	207	218	229	240	252	265	278	292	306	322	338
MAINT FUND	187	197	207	217	228	239	251	264	277	291	305	321	337	353	371	390	409	430	451	474	497
SUBTOTAL	6093	6190	6293	6400	6513	6631	6755	6885	7022	7166	7317	7476	7642	7817	8000	8193	8395	8607	8831	9065	9311
REV - EXPENSES	-3945	-3892	-3833	-3768	-3696	-3618	-3531	-3436	-3331	-3216	-3091	-2953	-2803	-2639	-2460	-2265	-2053	-1821	-1569	-1295	-997
TIP FEE R.R. 0/1	43	43	42	41	41	40	39	38	37	35	34	32	31	29	27	25	22	20	17	14	11
NET PM VAL R.R.	-34604																				
TIP FEE LF. 0/1	4.63	4.86	5.10	5.36	5.63	5.91	6.20	6.51	6.84	7.18	7.54	7.92	8.31	8.73	9.16	9.62	10.10	10.61	11.14	11.69	12.28
LF COST	-422	-443	-466	-489	-513	-539	-566	-594	-624	-655	-688	-722	-758	-796	-836	-878	-922	-968	-1016	-1067	-1121
NET PM VAL LF.	-6908																				

GUAM RESOURCE RECOVERY ASSUMPTION CASE 0

PLANT CAPACITY (TPD)	250.00
OPERATION (TPD)	250.00
CONST COST YR (10000)	32280.00
ANNUAL OUTPUT (MILLIONS KWH)	29.23
REV RATE ELECT YR 0 (10/KWH)	0.06
ANNUAL OUTPUT (MILLIONS LBS STEAM)	0.00
REV RATE STEAM YR 0 (10/1000LBS)	0.00
FINANCING FEES (TREDD FINANCED FUNDS)	25.00
FINANCING PROCEEDS (10000)	28245.00
EQUITY CONTRIBUTION (TCONST COST)	30.00
EQUITY CONTRIBUTION (10000)	9684.00
TOTAL REED CAPITAL	37929.00
REED DEBT COVERAGE FACTOR	1.25
TERM (YRS)	20.00
OPERATION COST YR 0 (10000)	1055.00
MAINT COST YR 0 (10000)	235.00
INS COST YR 0 (10000)	120.00
RESIDUE DISP COST YR 0 (10000)	110.00
LANDFILL COST YR 0 (10000)	365.00
DISCOUNT FACTOR	0.07
ELECT ESCAL FACTOR	0.07
OPER & MAINT ESCAL FACTOR	0.05
LANDFILL ESCAL FACTOR	0.05
COST OF BORROWED FUNDS	0.10
MAIN FUND YR 0 (10000)	162.00
LANDFILL TIP FEE YR 0	4.00

GUAM RESOURCE RECOVERY CASH FLOW CASE 2 GUANC2

YEAR	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
REVENUE																					
PRR ELECT	3008	3218	3443	3684	3942	4218	4514	4830	5168	5529	5916	6331	6774	7248	7755	8298	8879	9501	10166	10877	11639
SUBTOTAL	3008	3218	3443	3684	3942	4218	4514	4830	5168	5529	5916	6331	6774	7248	7755	8298	8879	9501	10166	10877	11639
EXPENSE																					
DEBT SERVICE	5428	5428	5428	5428	5428	5428	5428	5428	5428	5428	5428	5428	5428	5428	5428	5428	5428	5428	5428	5428	5428
OPERATION	1498	1573	1552	1734	1821	1912	2008	2108	2214	2324	2441	2563	2691	2825	2967	3115	3271	3434	3606	3786	3975
MAINT	341	358	376	395	415	436	457	480	504	529	556	584	613	644	676	710	745	782	821	862	906
INSUR	182	191	200	210	221	232	243	256	268	282	296	311	326	343	360	378	397	416	437	459	482
RESID DISP	178	187	196	205	217	227	238	251	263	276	290	305	320	336	353	370	389	408	429	450	473
MAINT FUND	245	258	270	284	298	313	329	345	362	381	400	420	440	463	486	510	535	562	590	620	651
SUBTOTAL	7873	7995	8123	8258	8400	8548	8704	8868	9040	9221	9410	9609	9818	10038	10268	10510	10764	11031	11311	11606	11915
REV - EXPENSES	-4865	-4777	-4680	-4574	-4467	-4330	-4190	-4038	-3872	-3691	-3494	-3279	-3045	-2790	-2513	-2212	-1885	-1531	-1146	-729	-276
TIP FEE R.R. 8/1	38	37	37	36	35	34	33	32	30	29	27	26	24	22	20	17	15	12	9	6	2
NET PR VAL R.R.	-19777																				
TIP FEE LF. 8/1	4.63	4.86	5.10	5.34	5.63	5.91	6.20	6.51	6.84	7.18	7.53	7.92	8.31	8.73	9.17	9.63	10.11	10.61	11.14	11.70	12.28
LF. COST	-591	-621	-652	-684	-718	-754	-792	-832	-873	-917	-965	-1011	-1061	-1114	-1170	-1229	-1290	-1355	-1422	-1493	-1568
NET PR VAL LF.	-9667																				

GUAM RESOURCE RECOVERY ASSUMPTION CASE 2

PLANT CAPACITY (TPD)	350.00
OPERATION (TPD)	350.00
CONST COST YR (\$000)	42250.00
ANNUAL OUTPUT (MILLIONS KWH)	40.92
REV RATE ELECT YR 0 (\$/KWH)	0.06
ANNUAL OUTPUT (MILLIONS LBS STEAM)	0.00
REV RATE STEAM YR 0 (\$/1000LBS)	0.00
FINANCING FEES (2% RECD FINANCED FUNDS)	25.00
FINANCING PROCEEDS (\$000)	36968.75
EQUITY CONTRIBUTION (2% CONST COST)	30.00
EQUITY CONTRIBUTION (\$000)	12675.00
TOTAL RECD CAPITAL	49643.75
RECD DEBT COVERAGE FACTOR	1.22
TERM (YRS)	20.00
OPERATION COST YR 0 (\$000)	1295.00
MAINT COST YR 0 (\$000)	295.00
INS COST YR 0 (\$000)	157.00
RESIDUE DISP COST YR 0 (\$000)	154.00
LANDFILL COST YR 0 (\$000)	511.00
DISCOUNT FACTOR	0.01
ELECT ESCAL FACTOR	0.01
OPER MAINT ESCAL FACTOR	0.06
LANDFILL ESCAL FACTOR	0.05
COST OF BORROWED FUNDS	0.10
MAINT FUND YR 0 (\$000)	212.00
LANDFILL TIP FEE YR 0	4.00

GUAM RESOURCE RECOVERY CASH FLOW CASE 3 GUAMCS

YEAR	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
REVENUE																					
PR ELECT	1288	1379	1475	1578	1689	1807	1934	2069	2214	2369	2535	2712	2902	3105	3322	3555	3804	4070	4355	4660	4986
SUBTOTAL	1288	1379	1475	1578	1689	1807	1934	2069	2214	2369	2535	2712	2902	3105	3322	3555	3804	4070	4355	4660	4986
EXPENSE																					
DEBT SERVICE	2756	2756	2756	2756	2756	2756	2756	2756	2756	2756	2756	2756	2756	2756	2756	2756	2756	2756	2756	2756	2756
OPERATION	941	988	1037	1089	1143	1201	1261	1324	1390	1459	1532	1609	1689	1774	1862	1956	2053	2156	2264	2377	2496
MAINT	194	205	216	224	238	250	262	275	289	303	319	334	351	369	387	406	427	448	471	494	519
INSUR	91	96	101	106	111	117	122	129	135	142	149	156	164	172	181	190	200	209	220	231	243
RESID DISP	74	80	84	88	93	97	102	107	113	118	124	131	137	144	151	159	167	175	184	193	203
MAINT FUND	124	130	136	141	150	158	166	174	183	192	202	212	222	233	245	257	270	284	298	313	328
SUBTOTAL	4183	4255	4330	4408	4491	4578	4669	4765	4865	4971	5081	5198	5320	5448	5583	5724	5872	6028	6192	6364	6544
REV - EXPENSES	-2895	-2876	-2855	-2830	-2802	-2771	-2735	-2696	-2651	-2602	-2547	-2486	-2418	-2343	-2260	-2169	-2069	-1958	-1837	-1704	-1558
TIP FEE R.R. & T	53	53	52	52	51	51	50	49	48	48	47	45	44	43	41	40	38	36	34	31	28
NET PR VAL R.R.	-27927																				
TIP FEE LF. & T	4.63	4.86	5.10	5.36	5.63	5.91	6.20	6.51	6.84	7.18	7.54	7.92	8.31	8.73	9.17	9.63	10.11	10.61	11.14	11.70	12.28
LF.COST	-253	-266	-279	-293	-308	-323	-339	-356	-374	-392	-412	-433	-454	-477	-501	-526	-552	-580	-609	-639	-671
NET PR VAL LF.	-4138																				

GUAM RESOURCE RECOVERY ASSUMPTION CASE 3

PLANT CAPACITY (TPD)	150.00
OPERATION (TPD)	150.00
CONST COST YR (\$000)	21450.00
ANNUAL OUTPUT (MILLIONS KWH)	17.53
REV RATE ELECT YR (\$/KWH)	0.06
ANNUAL OUTPUT (MILLIONS LBS STEAM)	0.00
REV RATE STEAM YR (\$/1000 LBS)	0.00
FINANCING FEES (2% REQ FINANCED FUNDS)	25.00
FINANCING PROCEEDS (\$000)	18768.75
EQUITY CONTRIBUTION (XCONST COST)	30.00
EQUITY CONTRIBUTION (\$000)	6435.00
TOTAL REQD CAPITAL	25203.75
REQD DEBT COVERAGE FACTOR	1.25
TERM (YRS)	20.00
OPERATION COST YR (\$000)	813.00
MAINT COST YR (\$000)	169.00
INS COST YR (\$000)	79.00
RESIDUE DISP COST YR (\$1000)	66.00
LANDFILL COST YR (\$1000)	219.00
DISCOUNT FACTOR	0.07
ELECT ESCAL FACTOR	0.07
OPER & MAINT ESCAL FACTOR	0.05
LANDFILL ESCAL FACTOR	0.05
COST OF BORROWED FUNDS	0.10
MAINT FUND YR (\$1000)	107.00
LANDFILL TIP FEE YR (\$)	4.00

0

LANDFILL TIP FEE YR 0 4.00

GUAM RESOURCE RECOVERY CASH FLOW CASE 4 GUAME4

YEAR	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
REVENUE																					
PWR ELECT	2148	2299	2460	2632	2816	3013	3224	3450	3691	3950	4226	4522	4839	5177	5540	5928	6342	6786	7261	7770	8314
SUBTOTAL	2148	2299	2460	2632	2816	3013	3224	3450	3691	3950	4226	4522	4839	5177	5540	5928	6342	6786	7261	7770	8314
EXPENSE																					
DEBT SERVICE	4147	4147	4147	4147	4147	4147	4147	4147	4147	4147	4147	4147	4147	4147	4147	4147	4147	4147	4147	4147	4147
OPERATION	1599	1679	1763	1851	1944	2041	2145	2250	2362	2481	2605	2735	2872	3015	3166	3324	3490	3665	3848	4041	4243
MAINT	340	352	375	394	413	434	456	479	503	528	554	582	611	641	673	707	743	780	819	860	903
INSUR.	174	182	191	201	211	221	233	244	256	269	283	297	312	327	344	361	379	398	418	439	460
RESID DISP	160	168	176	185	194	204	214	225	236	248	260	273	287	301	316	332	349	366	384	403	424
MAINT FUND	187	197	207	217	228	239	250	264	277	291	305	321	337	354	371	390	409	430	451	474	497
SUBTOTAL	6607	6730	6859	6995	7137	7286	7443	7608	7781	7963	8154	8354	8564	8785	9017	9261	9516	9785	10067	10363	10674
REV - EXPENSES	-4458	-4431	-4399	-4363	-4321	-4273	-4219	-4158	-4090	-4013	-3928	-3832	-3726	-3608	-3478	-3333	-3174	-2999	-2805	-2593	-2360
TIP FEE R.R. 6/T	49	46	48	48	47	47	46	46	45	44	43	42	41	40	38	37	35	33	31	28	26
NET PR VAL R.R.	-43007																				
TIP FEE LF. 6/T	4.63	4.85	5.10	5.36	5.63	5.91	6.20	6.51	6.84	7.18	7.54	7.92	8.31	8.73	9.16	9.62	10.10	10.61	11.14	11.69	12.28
LF. COST	-422	-443	-466	-489	-513	-539	-566	-594	-624	-655	-688	-722	-758	-796	-836	-878	-922	-968	-1016	-1067	-1121
NET PR VAL LF.	-6908																				

GUAM RESOURCE RECOVERY ASSUMPTION CASE 4

PLANT CAPACITY (TPD)	250.00
OPERATION (TPD)	250.00
CONST COST YR (\$000)	2280.00
ANNUAL OUTPUT (MILLIONS KWH)	29.25
REV RATE ELECT YR 0 (\$/KWH)	0.06
ANNUAL OUTPUT (MILLIONS LBS STEAM)	0.00
REV RATE STEAM YR 0 (\$/1000LBS)	0.00
FINANCING FEES (REQD FINANCED FUNDS)	25.00
FINANCING PROCEEDS (\$000)	18245.00
EQUITY CONTRIBUTION (CONST COST)	30.00
EQUITY CONTRIBUTION (\$000)	9684.00
TOTAL REQD CAPITAL	37929.00
REQD DEBT COVERAGE FACTOR	1.25
TERM (YRS)	20.00
OPERATION COST YR 0 (\$000)	1382.00
MAINT COST YR 0 (\$000)	294.00
INS COST YR 0 (\$000)	150.00
RESIDUE DISP COST YR 0 (\$000)	138.00
LANDFILL COST YR 0 (\$000)	365.00
DISCOUNT FACTOR	0.07
ELECT ESCAL FACTOR	0.07
OPER & MAINT ESCAL FACTOR	0.05
LANDFILL ESCAL FACTOR	0.05
COST OF BORROWED FUNDS	0.10
MAINT FUND YR 0 (\$000)	162.00
LANDFILL TIP FEE YR 0	4.00

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GUAM RESOURCE RECOVERY CASH FLOW CASE 5 GUAMES

YEAR	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
REVENUE																					
PWR ELECT	2148	2299	2460	2632	2816	3013	3224	3450	3691	3950	4226	4522	4839	5177	5540	5928	6342	6786	7261	7770	8314
SUBTOTAL	2148	2299	2460	2632	2816	3013	3224	3450	3691	3950	4226	4522	4839	5177	5540	5928	6342	6786	7261	7770	8314
EXPENSE																					
DEBT SERVICE	4147	4147	4147	4147	4147	4147	4147	4147	4147	4147	4147	4147	4147	4147	4147	4147	4147	4147	4147	4147	4147
OPERATION	915	961	1009	1059	1112	1168	1226	1288	1352	1420	1491	1565	1644	1726	1812	1903	1998	2098	2203	2313	2428
MAINT	204	214	225	236	248	260	273	287	301	316	332	348	366	384	403	423	445	467	490	515	540
INSUR	104	109	115	121	127	133	140	147	154	162	170	178	187	196	206	216	227	239	251	263	276
RESID DISP	96	101	106	111	117	123	129	135	142	149	156	164	172	181	190	200	210	220	231	243	255
MAINT FUND	187	197	207	217	226	239	251	264	277	291	305	321	337	353	371	390	409	430	451	474	497
SUBTOTAL	5653	5729	5808	5891	5976	6070	6166	6267	6373	6484	6601	6724	6852	6988	7130	7279	7435	7600	7772	7954	8144
REV - EXPENSES	-3505	-3430	-3348	-3259	-3167	-3056	-2942	-2817	-2681	-2534	-2375	-2201	-2014	-1810	-1590	-1351	-1093	-813	-511	-184	170
TIP FEE R.R. 4/T	38	38	37	36	35	33	32	31	29	28	26	24	22	20	17	15	12	9	6	2	-2
NET PR VAL R.R.	-27412																				
TIP FEE LF. 4/T	4.63	4.86	5.10	5.36	5.61	5.91	6.20	6.51	6.84	7.19	7.54	7.92	8.31	8.73	9.16	9.62	10.10	10.61	11.14	11.69	12.28
LF COST	-422	-443	-466	-489	-511	-539	-566	-594	-624	-655	-688	-722	-758	-796	-836	-878	-922	-968	-1016	-1067	-1121
NET PR VAL LF.	-6908																				

GUAM RESOURCE RECOVERY ASSUMPTION CASE 5

PLANT CAPACITY (TPD)	250.00
OPERATION (TPD)	250.00
CONST COST YR (10000)	32280.00
ANNUAL OUTPUT (MILLIONS KWH)	29.23
REV RATE ELECT YR 0 (10/KWH)	0.06
ANNUAL OUTPUT (MILLIONS LBS STEAM)	0.00
REV RATE STEAM YR 0 (10/1000LBS)	0.00
FINANCING FEES (1REQD FINANCED FUNDS)	25.00
FINANCING PROCEEDS (10000)	28245.00
EQUITY CONTRIBUTION (1CONST COST)	30.00
EQUITY CONTRIBUTION (10000)	9684.00
TOTAL REQD CAPITAL	37929.00
REQD DEBT COVERAGE FACTOR	1.25
TERM (YRS)	20.00
OPERATION COST YR 0 (10000)	791.00
MAINT COST YR 0 (10000)	176.00
INS COST YR 0 (10000)	90.00
RESIDUE DISP COST YR 0 (10000)	81.00
LANDFILL COST YR 0 (10000)	365.00
DISCOUNT FACTOR	0.07
ELECT ESCAL FACTOR	0.07
OPER & MAINT ESCAL FACTOR	0.05
LANDFILL ESCAL FACTOR	0.05
COST OF BORROWED FUNDS	0.10
MAINT FUND YR 0 (10000)	162.00
LANDFILL TIP FEE YR 0	4.00

GUAM RESOURCE RECOVERY CASH FLOW CASE 6

YEAR	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
REVENUE																					
PWR ELECT	2154	2304	2466	2638	2823	3020	3232	3458	3700	3959	4236	4533	4850	5190	5553	5942	6358	6803	7279	7783	8334
SUBTOTAL	2154	2304	2466	2638	2823	3020	3232	3458	3700	3959	4236	4533	4850	5190	5553	5942	6358	6803	7279	7783	8334
EXPENSE																					
DEBT SERVICE	5924	5924	5924	5924	5924	5924	5924	5924	5924	5924	5924	5924	5924	5924	5924	5924	5924	5924	5924	5924	5924
OPERATION	1221	1282	1346	1413	1484	1558	1636	1718	1803	1894	1988	2088	2192	2302	2417	2538	2664	2798	2938	3081	3239
MAINT	272	285	300	315	330	347	364	383	402	422	443	465	488	513	538	565	594	623	654	687	721
INSUR	139	146	153	161	169	177	186	195	205	215	226	237	249	262	275	289	303	318	334	351	368
RESID DISP	127	134	140	147	155	162	171	179	188	197	207	218	229	240	252	265	278	292	306	322	338
MAINT FUND	187	197	207	217	228	239	251	264	277	291	305	321	337	353	371	390	409	430	451	474	497
SUBTOTAL	7870	7968	8070	8177	8290	8408	8532	8663	8800	8943	9094	9253	9419	9591	9777	9970	10172	10385	10608	10842	11088
REV - EXPENSES	-5717	-5663	-5604	-5539	-5467	-5388	-5300	-5205	-5099	-4984	-4858	-4720	-4569	-4404	-4224	-4028	-3815	-3582	-3329	-3054	-2754
TIP FEE R.R. 8/T	63	62	61	61	60	59	58	57	56	55	53	52	50	48	46	44	42	39	36	33	30
NET PR VAL R.R.	-53761																				
TIP FEE LF. 8/T	4.63	4.86	5.10	5.36	5.63	5.91	6.20	6.51	6.84	7.18	7.54	7.92	8.31	8.73	9.16	9.62	10.10	10.61	11.14	11.69	12.28
LF.COST	-422	-443	-466	-489	-513	-539	-566	-594	-624	-655	-688	-722	-758	-796	-836	-878	-922	-968	-1016	-1067	-1121
NET PR VAL LF.	-6908																				

GUAM RESOURCE RECOVERY ASSUMPTION CASE 6

PLANT CAPACITY (TPD)	254.00
OPERATION (TPD)	254.00
CONST COST YR (\$000)	\$2284.00
ANNUAL OUTPUT (MILLIONS KWH)	29.30
REV RATE ELECT YR \$/KWH	0.06
ANNUAL OUTPUT (MILLIONS LBS STEAM)	0.00
REV RATE STEAM YR \$/1000LBS	0.00
FINANCING FEES (\$REQD FINANCED FUNDS)	22.00
FINANCING PROCEEDS(\$000)	40350.00
EQUITY CONTRIBUTION(\$CONST COST)	0.00
EQUITY CONTRIBUTION (\$000)	0.00
TOTAL REQD CAPITAL	40350.00
REQD DEBT COVERAGE FACTOR	1.25
TERM (YRS)	20.00
OPERATION COST YR \$(\$000)	1055.00
MAINT COST YR \$(\$000)	235.00
INS COST YR \$(\$000)	120.00
RESIDUE DISP COST YR \$(\$000)	110.00
LANDFILL COST YR \$(\$000)	365.00
DISCOUNT FACTOR	0.07
ELECT ESCAL FACTOR	0.07
OPER & MAINT ESCAL FACTOR	0.05
LANDFILL ESCAL FACTOR	0.05
COST OF BORROWED FUNDS	0.10
MAINT FUND YR \$(\$000)	162.00
LANDFILL TIP FEE YR \$	4.00

GUAM RESOURCE RECOVERY CASH FLOW CASE 7 GUAMC 7

YEAR	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
REVENUE																					
PMR ELECT	2148	2299	2460	2632	2816	3013	3224	3450	3691	3950	4226	4522	4839	5177	5540	5928	6342	6786	7261	7770	8314
SUBTOTAL	2148	2299	2460	2632	2816	3013	3224	3450	3691	3950	4226	4522	4839	5177	5540	5928	6342	6786	7261	7770	8314
EXPENSE																					
DEBT SERVICE	5184	5184	5184	5184	5184	5184	5184	5184	5184	5184	5184	5184	5184	5184	5184	5184	5184	5184	5184	5184	5184
OPERATION	1221	1282	1346	1413	1484	1558	1636	1718	1803	1894	1988	2088	2192	2302	2417	2538	2664	2798	2938	3084	3239
MAINT	272	285	300	315	330	347	364	383	402	422	443	465	488	513	538	565	594	623	654	687	721
INSUR	139	146	153	161	169	177	186	195	205	215	226	237	249	262	275	289	303	318	334	351	368
RESID DISP	127	134	140	147	155	162	171	179	188	197	207	218	229	240	252	265	278	292	306	322	338
MAINT FUND	187	197	207	217	228	239	251	264	277	291	305	321	337	353	371	390	409	430	451	474	497
SUBTOTAL	7130	7227	7329	7437	7549	7668	7792	7922	8059	8203	8354	8512	8679	8853	9037	9230	9432	9644	9867	10101	10347
REV - EXPENSES	-4981	-4928	-4870	-4805	-4733	-4654	-4568	-4472	-4368	-4253	-4128	-3990	-3840	-3676	-3497	-3302	-3089	-2858	-2606	-2332	-2034
TIP FEE R.R. & T	55	54	53	53	52	51	50	49	48	47	45	44	42	40	38	36	34	31	29	26	22
NET PR VAL R.R.	-45830																				
TIP FEE LF. & T	4.63	4.86	5.10	5.36	5.63	5.91	6.20	6.51	6.84	7.18	7.54	7.92	8.31	8.73	9.16	9.62	10.10	10.61	11.14	11.69	12.28
LF COST	-422	-443	-464	-489	-515	-539	-566	-594	-624	-655	-688	-722	-758	-796	-836	-878	-922	-968	-1016	-1067	-1121
NET PR VAL LF.	-4908																				

GUAM RESOURCE RECOVERY ASSUMPTION CASE 7

PLANT CAPACITY (TPD)	250.00
OPERATION (TPD)	250.00
CONST COST YR (\$000)	40350.00
ANNUAL OUTPUT (MILLIONS KWH)	29.23
REV RATE ELECT YR 0 (\$/KWH)	0.06
ANNUAL OUTPUT (MILLIONS LBS STEAM)	0.00
REV RATE STEAM YR 0 (\$/1000LBS)	0.00
FINANCING FEES (\$REDD FINANCED FUNDS)	25.00
FINANCING PROCEEDS (\$000)	35306.25
EQUITY CONTRIBUTION (\$CONST COST)	30.00
EQUITY CONTRIBUTION (\$000)	12105.00
TOTAL REDD CAPITAL	47411.25
REDD DEBT COVERAGE FACTOR	1.25
TERM (YRS)	20.00
OPERATION COST YR 0 (\$000)	1055.00
MAINT COST YR 0 (\$000)	235.00
INS COST YR 0 (\$000)	120.00
RESIDUE DISP COST YR 0 (\$000)	110.00
LANDFILL COST YR 0 (\$000)	365.00
DISCOUNT FACTOR	0.07
ELECT ESCAL FACTOR	0.07
OPER & MAINT ESCAL FACTOR	0.05
LANDFILL ESCAL FACTOR	0.05
COST OF BORROWED FUNDS	0.10
MAIN FUND YR 0 (\$000)	162.00
LANDFILL TIP FEE YR 0	4.00

GUAM RESOURCE RECOVERY CASH FLOW CASE B GUAMC B

YEAR	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
REVENUE																					
PWR ELECT	2148	2299	2460	2632	2816	3013	3224	3450	3691	3950	4226	4522	4839	5177	5540	5928	6342	6786	7261	7770	8314
SUBTOTAL	2148	2299	2460	2632	2816	3013	3224	3450	3691	3950	4226	4522	4839	5177	5540	5928	6342	6786	7261	7770	8314
EXPENSE																					
DEBT SERVICE	3110	3110	3110	3110	3110	3110	3110	3110	3110	3110	3110	3110	3110	3110	3110	3110	3110	3110	3110	3110	3110
OPERATION	1221	1282	1346	1413	1484	1558	1636	1718	1803	1894	1988	2088	2192	2302	2417	2538	2664	2798	2938	3084	3239
MAINT	272	285	300	315	330	347	364	383	402	422	443	465	488	513	538	565	594	623	654	687	721
INSUR	139	146	152	161	169	177	186	195	205	215	226	237	249	262	275	289	303	318	334	351	368
RESID DISP	127	134	140	147	155	162	171	179	188	197	207	218	229	240	252	265	278	292	306	322	338
MAINT FUND	187	197	207	217	228	239	251	264	277	291	305	321	337	353	371	390	409	430	451	474	497
SUBTOTAL	5056	5154	5254	5363	5476	5594	5718	5849	5986	6129	6280	6439	6605	6780	6963	7156	7358	7571	7794	8028	8274
REV - EXPENSES	-2908	-2855	-2794	-2731	-2660	-2581	-2494	-2399	-2294	-2180	-2054	-1917	-1767	-1603	-1424	-1229	-1016	-784	-532	-258	40
TIP FEE R.R. 8/1	32	31	31	30	29	28	27	26	25	24	23	21	19	18	16	13	11	9	6	3	0
NET PR VAL R.R.	-23370																				
TIP FEE LF. 8/1	4.63	4.86	5.16	5.56	5.83	5.91	6.20	6.51	6.84	7.18	7.54	7.92	8.31	8.73	9.16	9.62	10.10	10.61	11.14	11.69	12.28
LF COST	-422	-443	-466	-487	-513	-539	-566	-594	-624	-655	-688	-722	-758	-796	-836	-878	-922	-968	-1016	-1067	-1121
NET PR VAL LF.	-6908																				

GUAM RESOURCE RECOVERY ASSUMPTION CASE B

PLANT CAPACITY (TPD)	250.00
OPERATION (TPD)	250.00
CONST COST YR (\$000)	24210.00
ANNUAL OUTPUT (MILLIONS KWH)	29.23
REV RATE ELECT YR 0 (13/KWH)	0.06
ANNUAL OUTPUT (MILLIONS LBS STEAM)	0.00
REV RATE STEAM YR 0 (18/1000LBS)	0.00
FINANCING FEES (2% REQ FINANCED FUNDS)	25.00
FINANCING PROCEEDS (\$000)	21183.75
EQUITY CONTRIBUTION (CONST COST)	50.00
EQUITY CONTRIBUTION (\$000)	7263.00
TOTAL REQ CAPITAL	28416.75
REQD DEBT COVERAGE FACTOR	1.25
TERM (YRS)	20.00
OPERATION COST YR 0 (\$000)	1055.00
MAINT COST YR 0 (\$000)	235.00
INS COST YR 0 (\$000)	120.00
RESIDUE DISP COST YR 0 (\$000)	110.00
LANDFILL COST YR 0 (\$000)	365.00
DISCOUNT FACTOR	0.06
ELECT ESCAL FACTOR	0.06
OPER MAINT ESCAL FACTOR	0.05
LANDFILL ESCAL FACTOR	0.05
COST OF BORROWED FUNDS	0.10
MAINT FUND YR 0 (\$000)	162.00
LANDFILL TIP FEE YR 0	4.00

GUAM RESOURCE RECOVERY CASH FLOW CASE 9 GUANC9

YEAR	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
REVENUE																					
PWR ELECT	1229	1315	1407	1505	1611	1724	1844	1973	2112	2259	2417	2587	2768	2962	3169	3391	3628	3882	4154	4444	4756
SUBTOTAL	1229	1315	1407	1505	1611	1724	1844	1973	2112	2259	2417	2587	2768	2962	3169	3391	3628	3882	4154	4444	4756
EXPENSE																					
DEBT SERVICE	4147	4147	4147	4147	4147	4147	4147	4147	4147	4147	4147	4147	4147	4147	4147	4147	4147	4147	4147	4147	4147
OPERATION	1081	1135	1191	1251	1314	1379	1448	1521	1597	1676	1760	1848	1941	2038	2140	2247	2359	2477	2601	2731	2867
MAINT	234	245	258	271	284	298	313	329	345	363	381	400	420	441	463	486	510	536	562	591	620
INSUR	139	146	153	161	169	177	186	195	205	215	226	237	249	262	275	289	303	318	334	351	368
RESID DISP	76	80	84	88	93	97	102	107	113	118	124	131	137	144	151	159	167	175	184	193	203
MAINT FUND	187	197	207	217	228	239	251	264	277	291	305	321	337	353	371	390	409	430	451	474	497
SUBTOTAL	5864	5950	6040	6135	6234	6338	6448	6563	6684	6811	6944	7084	7231	7385	7547	7717	7895	8082	8279	8486	8703
REV - EXPENSES	-4635	-4635	-4633	-4629	-4623	-4615	-4604	-4590	-4572	-4551	-4526	-4497	-4463	-4423	-4378	-4326	-4267	-4200	-4126	-4041	-3947
TIP FEE R.R. 4/T	85	85	85	85	84	84	84	84	84	83	83	82	82	81	80	79	78	77	75	74	72
NET PR VAL R.R.	-48903																				
TIP FEE LF. 4/T	4.63	4.86	5.10	5.36	5.63	5.91	6.20	6.51	6.84	7.18	7.54	7.92	8.31	8.73	9.17	9.63	10.11	10.61	11.14	11.70	12.28
LF.COST	-253	-266	-279	-293	-308	-323	-339	-356	-374	-392	-412	-433	-454	-477	-501	-526	-552	-580	-609	-639	-671
NET PR VAL LF.	-4138																				

GUAM RESOURCE RECOVERY ASSUMPTION CASE 9

PLANT CAPACITY (TPD)	250.00
OPERATION(TPD)	150.00
CONST COST YR (\$000)	32280.00
ANNUAL OUTPUT (MILLIONS KWH)	16.72
REV RATE ELECT YR (\$/KWH)	0.06
ANNUAL OUTPUT (MILLIONS LBS STEAM)	0.00
REV RATE STEAM YR \$ (\$/1000LBS)	0.00
FINANCING FEES (XREDD FINANCED FUNDS)	25.00
FINANCING PROCEEDS(\$000)	28215.00
EQUITY CONTRIBUTION/(CONST COST)	30.00
EQUITY CONTRIBUTION (\$000)	9684.00
TOTAL RECD CAPITAL	37929.00
RECD DEBT COVERAGE FACTOR	1.25
TERM (YRS)	20.00
OPERATION COST YR (\$1000)	934.00
MAINT COST YR (\$1000)	202.00
INS COST YR (\$1000)	120.00
RESIDUE DISP COST YR (\$1000)	66.00
LANDFILL COST YR (\$1000)	219.00
DISCOUNT FACTOR	0.07
ELECT ESCAL FACTOR	0.07
OPER & MAINT ESCAL FACTOR	0.05
LANDFILL ESCAL FACTOR	0.05
COST OF BORROWED FUNDS	0.10
MAINT FUND YR (\$1000)	162.00
LANDFILL TIP FEE YR \$	4.00

GUAM RESOURCE RECOVERY CASH FLOW CASE 10

YEAR	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
REVENUE																					
PWR ELECT	4307	4609	4931	5276	5646	6041	6464	6916	7400	7918	8473	9066	9700	10379	11106	11883	12715	13605	14558	15577	16667
SUBTOTAL	4307	4609	4931	5276	5646	6041	6464	6916	7400	7918	8473	9066	9700	10379	11106	11883	12715	13605	14558	15577	16667
EXPENSE																					
DEBT SERVICE	4147	4147	4147	4147	4147	4147	4147	4147	4147	4147	4147	4147	4147	4147	4147	4147	4147	4147	4147	4147	4147
OPERATION	1497	1572	1651	1733	1820	1911	2006	2107	2212	2323	2439	2561	2689	2823	2964	3112	3268	3432	3603	3783	3972
MAINT	272	285	300	315	330	347	364	383	402	422	443	465	488	513	538	565	594	623	654	687	721
INSUR	139	146	153	161	169	177	186	195	205	215	226	237	249	262	275	289	303	318	334	351	368
RESID DISP	127	134	140	147	155	162	171	179	188	197	207	218	229	240	252	265	278	292	306	322	338
MAINT FUND	187	197	207	217	228	239	251	264	277	291	305	321	337	353	371	390	409	430	451	474	497
SUBTOTAL	6370	6481	6597	6720	6849	6984	7126	7274	7431	7595	7767	7948	8139	8338	8548	8768	8999	9241	9496	9763	10044
REV - EXPENSES	-2063	-1872	-1666	-1444	-1203	-943	-662	-358	-50	323	705	1117	1562	2041	2558	3116	3717	4364	5062	5813	6623
TIP FEE R.R. & T	23	21	18	16	13	10	7	4	0	-4	-8	-12	-17	-22	-28	-34	-41	-48	-55	-64	-73
NET PR VAL R.R.	3240																				
TIP FEE LF. & T	4.63	4.86	5.10	5.36	5.63	5.91	6.20	6.51	6.84	7.18	7.54	7.92	8.31	8.73	9.16	9.62	10.10	10.61	11.14	11.69	12.28
LF COST	-422	-443	-466	-489	-513	-539	-566	-594	-624	-655	-688	-722	-758	-796	-836	-878	-922	-968	-1016	-1067	-1121
NET PR VAL LF.	-6900																				

GUAM RESOURCE RECOVERY ASSUMPTION CASE 10

PLANT CAPACITY (TPD)	250.00
OPERATION (TPD)	250.00
CONST COST YR (\$000)	32280.00
ANNUAL OUTPUT (MILLIONS KWH)	29.30
REV RATE ELECT YR 0 (\$/KWH)	0.12
ANNUAL OUTPUT (MILLIONS LBS STEAM)	0.00
REV RATE STEAM YR 0 (\$/1000LBS)	0.00
FINANCING FEES (2REDD FINANCED FUNDS)	25.00
FINANCING PROCEEDS (\$000)	28245.00
EQUITY CONTRIBUTION (2CONST COST)	30.00
EQUITY CONTRIBUTION (\$000)	9684.00
TOTAL REDD CAPITAL	37929.00
REDD DEBT COVERAGE FACTOR	1.25
TERM (YRS)	20.00
OPERATION COST YR 0 (\$000)	1294.00
MAINT COST YR 0 (\$000)	235.00
INS COST YR 0 (\$000)	120.00
RESIDUE DISP COST YR 0 (\$000)	110.00
LANDFILL COST YR 0 (\$000)	365.00
DISCOUNT FACTOR	0.07
ELECT ESCAL FACTOR	0.07
OPER & MAINT ESCAL FACTOR	0.05
LANDFILL ESCAL FACTOR	0.05
COST OF BORROWED FUNDS	0.10
MAIN FUND YR 0 (\$000)	162.00
LANDFILL TIP FEE YR 0	4.00

GUAM RESOURCE RECOVERY CASH FLOW CASE 11

YEAR	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
REVENUE																					
PMR ELECT	2148	2299	2460	2632	2814	3013	3224	3450	3691	3950	4226	4522	4839	5177	5540	5928	6342	6786	7261	7770	8314
SUBTOTAL	2148	2299	2460	2632	2814	3013	3224	3450	3691	3950	4226	4522	4839	5177	5540	5928	6342	6786	7261	7770	8314
EXPENSE																					
DEBT SERVICE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
OPERATION	1221	1282	1346	1413	1484	1558	1636	1718	1803	1894	1988	2088	2192	2302	2417	2538	2664	2798	2938	3084	3239
MAINT	272	285	300	315	330	347	364	383	402	422	443	465	488	513	538	565	594	623	654	687	721
INSUR	139	146	153	161	169	177	186	195	205	215	226	237	249	262	275	289	303	318	334	351	368
RESID DISP	127	134	140	147	155	162	171	179	188	197	207	218	229	240	252	265	278	292	306	322	338
MAINT FUND	187	197	207	217	228	239	251	264	277	291	305	321	337	353	371	390	409	430	451	474	497
SUBTOTAL	1946	2045	2146	2253	2366	2484	2608	2738	2875	3019	3170	3328	3495	3670	3853	4046	4248	4460	4683	4918	5164
REV - EXPENSES	202	255	314	379	448	530	616	712	816	931	1056	1194	1344	1508	1687	1882	2094	2326	2578	2852	3150
TIP FEE R.R. 0/T	-2	-3	-3	-4	-5	-6	-7	-8	-9	-10	-12	-13	-15	-17	-18	-21	-23	-25	-28	-31	-35
NET PR VAL R.R.	10332																				
TIP FEE LF. 0/T	4.63	4.86	5.10	5.36	5.63	5.91	6.20	6.51	6.84	7.18	7.54	7.92	8.31	8.73	9.16	9.62	10.10	10.61	11.14	11.69	12.28
LF.COST	-422	-443	-466	-489	-513	-539	-566	-594	-624	-655	-688	-722	-758	-796	-836	-878	-922	-968	-1016	-1067	-1121
NET PR VAL LF.	-6908																				

GUAM RESOURCE RECOVERY ASSUMPTION CASE 11

PLANT CAPACITY (TPD)	250.00
OPERATION (TPD)	250.00
CONST COST YR (\$0000)	32280.00
ANNUAL OUTPUT (MILLIONS KWH)	29.23
REV RATE ELECT YR 0 (\$/KWH)	0.06
ANNUAL OUTPUT (MILLIONS LBS STEAM)	0.00
REV RATE STEAM YR 0 (\$/1000LBS)	0.00
FINANCING FEES (REQD FINANCED FUNDS)	0.00
FINANCING PROCEEDS (\$000)	0.00
EQUITY CONTRIBUTION (CONST COST)	0.00
EQUITY CONTRIBUTION (\$0000)	0.00
TOTAL REQD CAPITAL	0.00
REQD DEBT COVERAGE FACTOR	0.00
TERM (YRS)	0.00
OPERATION COST YR 0 (\$000)	1055.00
MAINT COST YR 0 (\$000)	235.00
INS COST YR 0 (\$000)	120.00
RESIDUE DISP COST YR 0 (\$000)	110.00
LANDFILL COST YR 0 (\$000)	365.00
DISCOUNT FACTOR	0.07
ELECT ESCAL FACTOR	0.07
OPER MAINT ESCAL FACTOR	0.05
LANDFILL ESCAL FACTOR	0.05
COST OF BORROWED FUNDS	0.10
MAINT FUND YR 0 (\$000)	162.00
LANDFILL TIP FEE YR 0	4.00

AMERICAN SANDA RESOURCE RECOVERY CASH FLOW CASE 1

YEAR	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
REVENUE																					
PWR ELECT	2148	2298	2459	2631	2816	3015	3224	3449	3691	3949	4226	4521	4838	5176	5539	5927	6341	6785	7260	7768	8312
SUBTOTAL	2148	2298	2459	2631	2816	3015	3224	3449	3691	3949	4226	4521	4838	5176	5539	5927	6341	6785	7260	7768	8312
EXPENSE																					
DEBT SERVICE	3162	3162	3162	3162	3162	3162	3162	3162	3162	3162	3162	3162	3152	3162	3162	3162	3162	3162	3162	3162	3162
OPERATION	1000	1050	1102	1157	1215	1274	1340	1407	1477	1551	1628	1710	1795	1885	1979	2078	2182	2291	2406	2526	2652
MAINT	163	171	180	189	198	208	219	230	241	253	266	279	293	308	323	339	356	374	393	412	433
INSUR	74	78	82	86	90	95	99	104	109	115	121	127	133	140	147	154	162	170	178	187	196
RESID DISP	34	35	37	39	41	43	45	47	50	52	55	57	60	63	66	70	73	77	81	85	89
MAINT FUND	100	104	110	115	121	127	133	140	147	154	162	170	179	188	197	207	217	228	239	251	264
SUBTOTAL	4532	4601	4673	4748	4827	4911	4998	5090	5186	5287	5394	5505	5622	5745	5875	6010	6153	6302	6459	6624	6797
REV - EXPENSES	-2384	-2302	-2213	-2117	-2012	-1898	-1774	-1641	-1495	-1338	-1168	-984	-785	-569	-336	-84	189	483	801	1145	1515
TIP FEE R.R. 8/1	65	63	61	58	55	52	49	45	41	37	32	27	21	16	9	2	-5	-13	-22	-31	-42
NET PR VAL R.R.	-14515																				
TIP FEE LF. 8/1	2.31	2.43	2.55	2.68	2.81	2.93	3.10	3.26	3.42	3.59	3.77	3.96	4.16	4.36	4.58	4.81	5.05	5.30	5.57	5.85	6.14
LF COST	-84	-89	-93	-98	-103	-108	-113	-119	-125	-131	-138	-144	-152	-159	-167	-176	-184	-194	-203	-213	-224
NET PR VAL LF.	-1382																				

AMERICAN SANDA RESOURCE RECOVERY ASSUMPTION CASE 1

PLANT CAPACITY (TPD)	100.00
OPERATION (TPD)	100.00
CONST COST YR (\$000)	17230.00
ANNUAL OUTPUT (MILLIONS KWH)	11.69
REV RATE ELECT YR 0 (\$/KWH)	0.15
ANNUAL OUTPUT (MILLIONS LBS STEAM)	0.00
REV RATE STEAM YR 0 (\$/1000LBS)	0.00
FINANCING FEES (2XRECD FINANCED FUNDS)	25.00
FINANCING PROCEEDS (\$000)	21537.50
EQUITY CONTRIBUTION (1XCONST COST)	0.00
EQUITY CONTRIBUTION (\$000)	0.00
TOTAL RECD CAPITAL	21537.50
RECD DEBT COVERAGE FACTOR	1.25
TERM (YRS)	28.00
OPERATION COST YR 0 (\$000)	664.00
MAINT COST YR 0 (\$000)	141.00
INS COST YR 0 (\$000)	64.00
RESIDUE DISP COST YR 0 (\$000)	29.00
LANDFILL COST YR 0 (\$000)	73.00
DISCOUNT FACTOR	0.07
ELECT ESCAL FACTOR	0.07
OPER & MAINT ESCAL FACTOR	0.05
LANDFILL ESCAL FACTOR	0.05
COST OF BORROWED FUNDS	0.10
MAINT FUND YR 0 (\$000)	86.00
LANDFILL TIP FEE YR 0	2.00

AMERICAN SANDA RESOURCE RECOVERY CASH FLOW CASE 2

YEAR	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
REVENUE																					
PWR ELECT	5221	3447	3688	3946	4222	4518	4834	5172	5535	5922	6336	6780	7255	7762	8306	8887	9509	10175	10887	11649	12465
SUBTOTAL	5221	3447	3688	3946	4222	4518	4834	5172	5535	5922	6336	6780	7255	7762	8306	8887	9509	10175	10887	11649	12465
EXPENSE																					
DEBT SERVICE	4374	4374	4374	4374	4374	4374	4374	4374	4374	4374	4374	4374	4374	4374	4374	4374	4374	4374	4374	4374	4374
OPERATION	1285	1350	1417	1488	1562	1641	1723	1809	1899	1994	2094	2199	2308	2424	2545	2672	2806	2946	3094	3248	3411
MAINT	209	220	231	242	255	267	281	295	309	325	341	358	376	395	415	435	457	480	504	529	556
INSUR	102	107	112	118	124	130	136	143	150	158	166	174	183	192	202	212	222	233	245	257	270
RESID DISP	51	53	56	59	62	65	68	72	75	79	83	87	91	96	101	106	111	117	123	129	135
MAINT FUND	138	145	152	159	167	176	185	194	203	214	224	235	247	260	273	286	301	316	331	348	365
SUBTOTAL	6159	6248	6342	6440	6544	6652	6766	6886	7011	7143	7282	7427	7580	7740	7908	8085	8271	8465	8670	8885	9110
REV - EXPENSES	-2938	-2801	-2654	-2494	-2321	-2134	-1932	-1713	-1477	-1221	-945	-647	-325	23	398	802	1239	1710	2217	2765	3354
TIP FEE R.R. & T	54	51	48	46	42	39	35	31	27	22	17	12	6	0	-7	-15	-23	-31	-40	-50	-61
NET PW VAL R.R.	-13374																				
TIP FEE LF. & T	2.31	2.43	2.55	2.67	2.81	2.95	3.10	3.25	3.41	3.58	3.76	3.95	4.15	4.36	4.57	4.80	5.04	5.29	5.56	5.84	6.13
LF. COST	-127	-133	-140	-147	-154	-162	-170	-179	-188	-197	-207	-217	-228	-239	-251	-264	-277	-291	-306	-321	-337
NET PW VAL LF.	-2077																				

AMERICAN SANDA RESOURCE RECOVERY ASSUMPTION CASE 2

PLANT CAPACITY (TPD)	150.00
OPERATION (TPD)	150.00
CONST COST YR (\$000)	23830.00
ANNUAL OUTPUT (MILLIONS KWH)	17.53
REV RATE ELECT YR 0 (\$/KWH)	0.15
ANNUAL OUTPUT (MILLIONS LBS STEAM)	0.00
REV RATE STEAM YR 0 (\$/1000LBS)	0.00
FINANCING FEES (2REB9 FINANCED FUNDS)	25.00
FINANCING PROCEEDS (\$000)	29787.50
EQUITY CONTRIBUTION (CONST COST)	0.00
EQUITY CONTRIBUTION (\$000)	0.00
TOTAL REB9 CAPITAL	29787.50
REB9 DEBT COVERAGE FACTOR	1.25
TERM (YRS)	20.00
OPERATION COST YR 0 (\$000)	1111.00
MAINT COST YR 0 (\$000)	181.00
INS COST YR 0 (\$000)	88.00
RESIDUE DISP COST YR 0 (\$000)	44.00
LANDFILL COST YR 0 (\$000)	109.50
DISCOUNT FACTOR	0.07
ELECT ESCAL FACTOR	0.07
OPER & MAINT ESCAL FACTOR	0.05
LANDFILL ESCAL FACTOR	0.05
COST OF BORROWED FUNDS	0.10
MAINT FUND YR 0 (\$000)	119.00
LANDFILL TIP FEE YR 0	2.00

AMERICAN SANDA RESOURCE RECOVERY CASH FLOW CASE 3

YEAR	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
REVENUE																					
PER ELECT	1075	1150	1231	1317	1409	1508	1613	1726	1847	1976	2115	2263	2421	2590	2772	2966	3173	3396	3633	3888	4160
SUBTOTAL	1075	1150	1231	1317	1409	1508	1613	1726	1847	1976	2115	2263	2421	2590	2772	2966	3173	3396	3633	3888	4160
EXPENSE																					
DEBT SERVICE	1817	1817	1817	1817	1817	1817	1817	1817	1817	1817	1817	1817	1817	1817	1817	1817	1817	1817	1817	1817	1817
OPERATION	710	746	782	822	863	907	952	1000	1050	1102	1157	1215	1276	1340	1407	1477	1551	1628	1710	1795	1885
MAINT	111	117	122	129	135	142	149	156	164	172	181	190	199	209	220	231	242	255	267	281	295
INSUR	43	45	47	50	52	55	57	60	63	66	70	73	77	81	85	89	93	98	103	108	114
RESID DISP	17	18	19	20	21	22	23	24	26	27	28	30	31	33	34	36	38	40	42	44	46
MAINT FUND	58	61	64	67	70	74	78	81	85	90	94	99	104	109	115	120	126	133	139	146	153
SUBTOTAL	2756	2803	2852	2905	2959	3016	3076	3139	3205	3274	3347	3424	3504	3588	3677	3770	3868	3970	4078	4191	4310
REV - EXPENSES	-1682	-1653	-1622	-1588	-1550	-1508	-1463	-1413	-1358	-1298	-1233	-1161	-1083	-998	-905	-804	-694	-575	-445	-303	-150
TIP FEE R.R./T	92	91	89	87	85	83	80	77	74	71	68	64	59	55	50	44	38	31	24	17	8
NET PR VAL R.R.	-13959																				
TIP FEE LF./T	2.31	2.43	2.55	2.67	2.81	2.95	3.10	3.25	3.41	3.58	3.76	3.95	4.15	4.36	4.57	4.80	5.04	5.29	5.56	5.84	6.13
LF.COST	-42	-44	-46	-49	-51	-54	-56	-59	-62	-65	-68	-72	-75	-79	-83	-87	-92	-96	-101	-106	-111
NET PR VAL LF.	-687																				

AMERICAN SANDA RESOURCE RECOVERY ASSUMPTION CASE 3

PLANT CAPACITY (TPD)	50.00
OPERATION (TPD)	50.00
CONST COST YR (\$000)	9900.00
ANNUAL OUTPUT (MILLIONS KWH)	5.65
REV RATE ELECT YR 0 (\$/KWH)	0.15
ANNUAL OUTPUT (MILLIONS LBS STEAM)	0.00
REV RATE STEAM YR 0 (\$/1000LBS)	0.00
FINANCING FEES (2RF) FINANCED FUNDS)	25.00
FINANCING PROCEEDS (\$000)	12375.00
EQUITY CONTRIBUTION (CONST COST)	0.00
EQUITY CONTRIBUTION (\$000)	0.00
TOTAL RECD CAPITAL	12375.00
RECD DEBT COVERAGE FACTOR	1.25
TERM (YRS)	20.00
OPERATION COST YR 0 (\$000)	614.00
MAINT COST YR 0 (\$000)	96.00
INS COST YR 0 (\$000)	37.00
RESIDUE DISP COST YR 0 (\$000)	15.00
LANDFILL COST YR 0 (\$000)	36.50
DISCOUNT FACTOR	0.07
ELECT ESCAL FACTOR	0.07
OPER & MAINT ESCAL FACTOR	0.05
LANDFILL ESCAL FACTOR	0.05
COST OF BORROWED FUNDS	0.10
MAINT FUND YR 0 (\$000)	50.00
LANDFILL TIP FEE YR 0	2.00

AMERICAN SANDA RESOURCE RECOVERY CASH FLOW CASE 4

YEAR	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
REVENUE																					
PRR ELECT	2148	2298	2459	2631	2816	3013	3224	3449	3691	3949	4226	4521	4838	5176	5539	5927	6341	6785	7260	7768	8312
SUBTOTAL	2148	2298	2459	2631	2816	3013	3224	3449	3691	3949	4226	4521	4838	5176	5539	5927	6341	6785	7260	7768	8312
EXPENSE																					
DEBT SERVICE	3162	3162	3162	3162	3162	3162	3162	3162	3162	3162	3162	3162	3162	3162	3162	3162	3162	3162	3162	3162	3162
OPERATION	1250	1312	1378	1447	1519	1595	1675	1758	1846	1938	2035	2137	2244	2356	2474	2598	2728	2864	3007	3158	3315
MAINT	204	214	225	236	248	260	273	287	301	316	332	348	366	384	403	423	445	467	490	515	540
INSUR	93	97	102	107	113	118	124	130	137	144	151	158	166	175	183	192	202	212	223	234	246
RESID DISP	42	44	46	49	51	54	56	59	62	65	68	72	75	79	83	87	92	96	101	106	111
MAINT FUND	100	104	110	115	121	127	133	140	147	154	162	170	179	188	197	207	217	228	239	251	264
SUBTOTAL	4849	4934	5022	5115	5213	5316	5423	5536	5655	5780	5910	6048	6192	6344	6503	6670	6845	7029	7223	7426	7639
REV - EXPENSES	-2701	-2635	-2563	-2484	-2397	-2303	-2200	-2087	-1964	-1831	-1685	-1527	-1354	-1167	-964	-743	-504	-244	38	343	673
TIP FEE R.R. 8/1	74	72	70	68	66	63	60	57	54	50	46	42	37	32	26	20	14	7	-1	-9	-18
NET PR VAL R.R.	-19795																				
TIP FEE LF. 8/1	2.31	2.43	2.55	2.68	2.81	2.95	3.10	3.26	3.42	3.59	3.77	3.96	4.16	4.36	4.58	4.81	5.05	5.30	5.57	5.85	6.14
LF.COST	-84	-89	-93	-98	-103	-108	-113	-119	-125	-131	-138	-144	-152	-159	-167	-176	-184	-194	-203	-213	-224
NET PR VAL LF.	-1382																				

AMERICAN SANDA RESOURCE RECOVERY ASSUMPTION CASE 4

PLANT CAPACITY (TPD)	100.00
OPERATION(TPD)	100.00
CONST COST YR (\$0000)	17230.00
ANNUAL OUTPUT (MILLIONS KWH)	11.69
REV RATE ELECT YR 0 (\$/KWH)	0.15
ANNUAL OUTPUT (MILLIONS LBS STEAM)	0.00
REV RATE STEAM YR 0 (\$/1000LBS)	0.00
FINANCING FEES (2REQD FINANCED FUNDS)	25.00
FINANCING PROCEEDS(\$0000)	21537.50
EQUITY CONTRIBUTION(2CONST COST)	0.00
EQUITY CONTRIBUTION (\$0000)	0.00
TOTAL REQD CAPITAL	21537.50
REQD DEBT COVERAGE FACTOR	1.25
TERM (YRS)	20.00
OPERATION COST YR 0(\$0000)	1080.00
MAINT COST YR 0(\$0000)	176.00
INS COST YR 0(\$0000)	80.00
RESIDUE DISP COST YR 0(\$0000)	36.25
LANDFILL COST YR 0(\$0000)	73.00
DISCOUNT FACTOR	0.07
ELECT ESCAL FACTOR	0.07
OPER MAINT ESCAL FACTOR	0.05
LANDFILL ESCAL FACTOR	0.05
COST OF BORROWED FUNDS	0.10
MAINT FUND YR 0(\$0000)	86.00
LANDFILL TIP FEE YR 0	2.00

AMERICAN SANDA RESOURCE RECOVERY CASH FLOW CASE 5

YEAR	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
REVENUE																					
PRM ELECT	2148	2298	2459	2631	2816	3013	3224	3449	3691	3949	4226	4521	4838	5176	5539	5927	6341	6785	7260	7768	8312
SUBTOTAL	2148	2298	2459	2631	2816	3013	3224	3449	3691	3949	4226	4521	4838	5176	5539	5927	6341	6785	7260	7768	8312
EXPENSE																					
DEBT SERVICE	3162	3162	3162	3162	3162	3162	3162	3162	3162	3162	3162	3162	3162	3162	3162	3162	3162	3162	3162	3162	3162
OPERATION	750	787	827	868	911	957	1005	1055	1108	1163	1221	1282	1346	1414	1484	1559	1637	1718	1804	1895	1989
MAINT	123	129	135	142	149	157	164	173	181	190	200	210	220	231	243	255	268	281	295	310	325
INSUR	56	58	61	64	68	71	74	78	82	86	90	95	100	105	110	115	121	127	134	140	147
RESID DISP	25	27	28	29	31	32	34	36	38	39	41	44	46	48	50	53	56	58	61	64	68
MAINT FUND	100	134	110	115	121	127	133	140	147	154	162	170	179	188	197	207	217	228	239	251	264
SUBTOTAL	4215	4268	4323	4381	4442	4506	4573	4644	4718	4796	4877	4963	5053	5148	5247	5351	5461	5575	5696	5823	5956
REV - EXPENSES	-2067	-1967	-1864	-1750	-1626	-1493	-1350	-1194	-1027	-847	-652	-442	-215	29	292	575	881	1210	1564	1946	2356
TIP FEE R.R. 0/1	57	54	51	48	45	41	37	33	28	23	18	12	6	-1	-8	-16	-24	-33	-43	-53	-65
NET PR VAL R.R.	-9329																				
TIP FEE LF. 0/1	2.31	2.15	2.55	2.68	2.81	2.95	3.10	3.26	3.42	3.59	3.77	3.96	4.16	4.36	4.58	4.81	5.05	5.30	5.57	5.85	6.14
LF. COST	-84	-87	-93	-98	-103	-108	-113	-119	-125	-131	-138	-144	-152	-159	-167	-176	-184	-194	-203	-213	-224
NET PR VAL LF.	-1382																				

AMERICAN SANDA RESOURCE RECOVERY ASSUMPTION CASE 5

PLANT CAPACITY (TPD)	100.00
OPERATION (TPD)	100.00
CONST COST YR (\$000)	17230.00
ANNUAL OUTPUT (MILLIONS KWH)	11.69
REV RATE ELECT YR 0 (\$/KWH)	0.15
ANNUAL OUTPUT (MILLIONS LBS STEAM)	0.00
REV RATE STEAM YR 0 (\$/1000LBS)	0.00
FINANCING FEES (2REDD FINANCED FUNDS)	25.00
FINANCING PROCEEDS (\$000)	21537.50
EQUITY CONTRIBUTION (2CONST COST)	0.00
EQUITY CONTRIBUTION (\$000)	0.00
TOTAL REDD CAPITAL	21537.50
REDD DEBT COVERAGE FACTOR	1.25
TERM (YRS)	20.00
OPERATION COST YR 0 (\$000)	48.00
MAINT COST YR 0 (\$000)	106.00
INS COST YR 0 (\$000)	48.00
RESIDUE DISP COST YR 0 (\$000)	22.00
LANDFILL COST YR 0 (\$000)	73.00
DISCOUNT FACTOR	0.07
ELECT ESCAL FACTOR	0.07
OPER & MAINT ESCAL FACTOR	0.05
LANDFILL ESCAL FACTOR	0.05
COST OF BORROWED FUNDS	0.10
MAIN FUND YR 0 (\$000)	86.00
LANDFILL TIP FEE YR 0	2.00

AMERICAN SANDA RESOURCE RECOVERY CASH FLOW CASE 6

YEAR	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
REVENUE																					
PWR ELECT	2148	2298	2459	2631	2816	3013	3224	3449	3691	3949	4226	4521	4838	5176	5539	5927	6341	6785	7260	7768	8312
SUBTOTAL	2148	2298	2459	2631	2816	3013	3224	3449	3691	3949	4226	4521	4838	5176	5539	5927	6341	6785	7260	7768	8312
EXPENSE																					
DEBT SERVICE	2214	2214	2214	2214	2214	2214	2214	2214	2214	2214	2214	2214	2214	2214	2214	2214	2214	2214	2214	2214	2214
OPERATION	1000	1050	1102	1157	1215	1276	1340	1407	1477	1551	1628	1710	1795	1885	1979	2078	2182	2291	2406	2526	2652
MAINT	163	171	180	189	198	208	219	230	241	253	266	279	293	308	323	339	356	374	393	412	433
INSUR	74	78	82	86	90	95	99	104	109	115	121	127	133	140	147	154	162	170	178	187	196
RESID DISP	34	35	37	39	41	43	45	47	50	52	55	57	60	63	66	70	73	77	81	85	89
MAINT FUND	100	104	110	115	121	127	133	140	147	154	162	170	179	188	197	207	217	228	239	251	264
SUBTOTAL	3583	3652	3724	3799	3879	3962	4049	4141	4238	4339	4445	4557	4674	4797	4926	5061	5204	5353	5510	5675	5848
REV - EXPENSES	-1435	-1354	-1265	-1168	-1063	-949	-826	-692	-547	-390	-219	-35	164	380	613	865	1138	1432	1750	2093	2464
TIP FEE R.R. 8/T	39	37	35	32	29	26	23	19	15	11	6	1	-4	-10	-17	-24	-31	-39	-48	-57	-68
NET PW VAL R.R.	-4236																				
TIP FEE LF. 8/T	2.31	2.43	2.53	2.68	2.81	2.95	3.10	3.26	3.42	3.59	3.77	3.96	4.16	4.36	4.58	4.81	5.05	5.30	5.57	5.85	6.14
LF COST	-84	-89	-93	-98	-103	-108	-113	-119	-125	-131	-138	-144	-152	-159	-167	-176	-184	-194	-203	-213	-224
NET PW VAL LF.	-1382																				

AMERICAN SANDA RESOURCE RECOVERY ASSUMPTION CASE 6

PLANT CAPACITY (TPD)	100.00
OPERATION (TPD)	100.00
CONST COST YR (\$000)	17230.00
ANNUAL OUTPUT (MILLIONS KWH)	11.69
REV RATE ELECT YR 0 (\$/KWH)	0.15
ANNUAL OUTPUT (MILLIONS LBS STEAM)	0.00
REV RATE STEAM YR 0 (\$/1000LBS)	0.00
FINANCING FEES (XREDD FINANCED FUNDS)	25.00
FINANCING PROCEEDS (\$000)	15076.25
EQUITY CONTRIBUTION (XCONST COST)	30.00
EQUITY CONTRIBUTION (\$000)	5169.00
TOTAL RECD CAPITAL	20245.25
RECD DEBT COVERAGE FACTOR	1.25
TERM (YRS)	20.00
OPERATION COST YR 0 (\$000)	864.00
MAINT COST YR 0 (\$000)	141.00
INS COST YR 0 (\$000)	64.00
RESIDUE DISP COST YR 0 (\$000)	29.00
LANDFILL COST YR 0 (\$000)	73.00
DISCOUNT FACTOR	0.07
ELECT ESCAL FACTOR	0.07
OPER MAINT ESCAL FACTOR	0.05
LANDFILL ESCAL FACTOR	0.05
COST OF BORROWED FUNDS	0.10
MAINT FUND YR 0 (\$000)	86.00
LANDFILL TIP FEE YR 0	2.00

AMERICAN SODA RESOURCE RECOVERY CASH FLOW BASE 7

YEAR	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
REVENUE																					
PWR ELECT	950	1016	1088	1144	1215	1332	1426	1525	1632	1747	1869	2000	2140	2289	2450	2621	2805	3001	3211	3436	3676
SUBTOTAL	950	1016	1088	1144	1215	1332	1426	1525	1632	1747	1869	2000	2140	2289	2450	2621	2805	3001	3211	3436	3676
EXPENSE																					
DEBT SERVICE	3162	3162	3162	3162	3162	3162	3162	3162	3162	3162	3162	3162	3162	3162	3162	3162	3162	3162	3162	3162	3162
OPERATION	855	898	941	970	1039	1091	1146	1203	1263	1326	1393	1462	1535	1612	1693	1778	1866	1960	2058	2161	2269
MAINT	138	145	152	159	167	176	185	194	203	214	224	235	247	260	273	286	301	316	331	348	365
INSUR	74	78	82	86	90	95	99	104	109	115	121	127	133	140	147	154	162	170	178	187	196
RESID DISP	17	18	19	20	21	22	23	24	26	27	28	30	31	33	34	36	38	40	42	44	46
MAINT FUND	100	104	110	115	121	127	133	140	147	154	162	170	179	188	197	207	217	228	239	251	264
SUBTOTAL	4346	4405	4467	4512	4601	4673	4748	4828	4911	4998	5090	5187	5288	5394	5506	5623	5746	5875	6011	6153	6303
REV - EXPENSES	-3396	-3389	-3380	-3369	-3356	-3340	-3323	-3302	-3279	-3252	-3221	-3187	-3148	-3102	-3056	-3002	-2941	-2874	-2800	-2718	-2627
TIP FEE R.R. & T	186	186	185	185	184	183	182	181	180	178	177	175	173	170	167	164	161	157	153	149	144
MET PR VAL R.R.	-34981																				
TIP FEE LF. & T	2.31	2.43	2.55	2.67	2.81	2.95	3.10	3.25	3.41	3.58	3.76	3.95	4.12	4.36	4.57	4.80	5.04	5.29	5.56	5.84	6.13
LF. COST	-42	-44	-46	-49	-51	-54	-56	-59	-62	-65	-68	-72	-75	-79	-83	-87	-92	-96	-101	-106	-111
MET PR VAL LF.	-687																				

AMERICAN SODA RESOURCE RECOVERY ASSUMPTION CASE 7

PLANT CAPACITY (TPH)	100.00
OPERATION (TPH)	50.00
CONST COST YR (\$1000)	17230.00
ANNUAL OUTPUT (MILLIONS KWH)	5.17
REV RATE ELECT YR (\$/KWH)	0.15
ANNUAL OUTPUT (MILLIONS LBS STEAM)	0.30
REV RATE STEAM YR (\$/1000LBS)	0.30
FINANCING FEES (3REDD FINANCED FUNDS)	25.00
FINANCING PROCEEDS (\$1000)	21537.50
EQUITY CONTRIBUTION (CONST COST)	0.00
EQUITY CONTRIBUTION (\$1000)	0.00
TOTAL REDD CAPITAL	21537.50
REDD DEBT COVERAGE FACTOR	1.25
TERM (YRS)	20.00
OPERATION COST YR (\$1000)	739.00
MAINT COST YR (\$1000)	119.00
INS COST YR (\$1000)	64.00
RESIDUE DISP COST YR (\$1000)	15.00
LANDFILL COST YR (\$1000)	36.50
DISCOUNT FACTOR	0.07
ELECT ESCAL FACTOR	0.07
OPER & MAINT ESCAL FACTOR	0.05
LANDFILL ESCAL FACTOR	0.05
COST OF BORROWED FUNDS	0.10
MAIN FUND YR (\$1000)	86.00
LANDFILL TIP FEE YR (\$)	2.00

AMERICAN SAROA RESOURCE RECOVERY CASH FLOW CASE B

YEAR	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
REVENUE																					
PWR ELECT	5012	5363	5738	6140	6570	7030	7522	8048	8612	9215	9860	10550	11288	12078	12924	13829	14797	15832	16941	18126	19395
SUBTOTAL	5012	5363	5738	6140	6570	7030	7522	8048	8612	9215	9860	10550	11288	12078	12924	13829	14797	15832	16941	18126	19395
EXPENSE																					
DEBT SERVICE	3162	3162	3162	3162	3162	3162	3162	3162	3162	3162	3162	3162	3162	3162	3162	3162	3162	3162	3162	3162	3162
OPERATION	1313	1379	1448	1520	1596	1676	1760	1848	1940	2037	2139	2246	2358	2476	2600	2730	2867	3010	3160	3318	3484
MAINT	163	171	180	189	198	208	219	230	241	253	266	279	293	308	323	339	356	374	393	412	433
INSUR	74	78	82	86	90	95	99	104	109	115	121	127	133	140	147	154	162	170	178	187	196
RESID DISP	34	35	37	39	41	43	45	47	50	52	55	57	60	63	66	70	73	77	81	85	89
MAINT FUND	100	104	110	115	121	127	133	140	147	154	162	170	179	188	197	207	217	228	239	251	264
SUBTOTAL	4846	4930	5018	5111	5208	5311	5418	5531	5649	5774	5904	6041	6185	6337	6495	6662	6837	7021	7214	7416	7629
REV - EXPENSES	166	433	720	1029	1361	1719	2104	2517	2962	3441	3955	4508	5103	5742	6429	7167	7960	8812	9727	10710	11766
TIP FEE R.R. 0/T	-5	-12	-20	-28	-37	-47	-58	-69	-81	-94	-108	-124	-140	-157	-176	-196	-218	-241	-266	-293	-322
NET PR VAL R.R.	16567																				
TIP FEE LF. 0/T	2.31	2.43	2.55	2.68	2.81	2.95	3.10	3.26	3.42	3.59	3.77	3.96	4.16	4.36	4.58	4.81	5.05	5.30	5.57	5.85	6.14
LF COST	-84	-89	-93	-98	-103	-108	-113	-119	-125	-131	-138	-144	-152	-159	-167	-176	-184	-194	-203	-213	-224
NET PR VAL LF.	-1382																				

AMERICAN SAROA RESOURCE RECOVERY ASSUMPTION CASE B

PLANT CAPACITY (TPD)	100.00
OPERATION (TPD)	100.00
CONST COST YR (\$000)	17230.00
ANNUAL OUTPUT (MILLIONS KWH)	11.69
REV RATE ELECT YR 0 (\$/KWH)	0.33
ANNUAL OUTPUT (MILLIONS LBS STEAM)	0.00
REV RATE STEAM YR 0 (\$/1000LBS)	0.00
FINANCING FEES (ZERO FINANCED FUNDS)	25.00
FINANCING PROCEEDS (\$000)	21537.50
EQUITY CONTRIBUTION (ZCONST COST)	0.00
EQUITY CONTRIBUTION (\$000)	0.00
TOTAL RECD CAPITAL	21537.50
REBT DEBT COVERAGE FACTOR	1.25
TERM (YRS)	20.00
OPERATION COST YR 0 (\$000)	1135.00
MAINT COST YR 0 (\$000)	141.00
INS COST YR 0 (\$000)	64.00
RESIDUE DISP COST YR 0 (\$000)	29.00
LANDFILL COST YR 0 (\$000)	73.00
DISCOUNT FACTOR	0.07
ELECT ESCAL FACTOR	0.07
OPER MAINT ESCAL FACTOR	0.05
LANDFILL ESCAL FACTOR	0.05
COST OF BORROWED FUNDS	0.10
MAINT FUND YR 0 (\$000)	86.00
LANDFILL TIP FEE YR 0	2.00

AMERICAN SANDA RESOURCE RECOVERY CASH FLOW CASE 9

YEAR	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
REVENUE																					
PR ELECT	2148	2298	2459	2631	2816	3013	3224	3449	3691	3949	4226	4521	4838	5176	5539	5927	6341	6785	7260	7768	8312
SUBTOTAL	2148	2298	2459	2631	2816	3013	3224	3449	3691	3949	4226	4521	4838	5176	5539	5927	6341	6785	7260	7768	8312
EXPENSE																					
DEBT SERVICE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
OPERATION	1000	1050	1102	1157	1215	1276	1340	1407	1477	1551	1628	1710	1795	1885	1979	2078	2182	2291	2406	2526	2652
MAINT	163	171	180	189	198	208	219	230	241	253	266	279	293	308	323	339	356	374	393	412	433
INSUR	74	78	82	86	90	95	99	104	109	115	121	127	133	140	147	154	162	170	178	187	196
RESID DISP	34	35	37	39	41	43	45	47	50	52	55	57	60	63	66	70	73	77	81	85	89
MAINT FUND	100	104	110	115	121	127	133	140	147	154	162	170	179	188	197	207	217	228	239	251	264
SUBTOTAL	1370	1438	1510	1586	1665	1748	1836	1928	2024	2125	2231	2343	2460	2583	2712	2848	2990	3140	3297	3462	3635
REV - EXPENSES	778	860	949	1045	1151	1264	1388	1522	1667	1824	1994	2178	2378	2593	2827	3079	3351	3645	3963	4307	4678
TIP FEE R.R. 0/T	-21	-24	-28	-29	-32	-35	-38	-42	-46	-50	-55	-60	-65	-71	-77	-84	-92	-100	-109	-118	-128
NET PR VAL R.R.	19750																				
TIP FEE LF. 0/T	2.31	2.43	2.52	2.68	2.81	2.95	3.10	3.26	3.42	3.59	3.77	3.96	4.16	4.36	4.58	4.81	5.05	5.30	5.57	5.85	6.14
LF.COST	-84	-89	-92	-98	-103	-108	-113	-119	-125	-131	-138	-144	-152	-159	-167	-176	-184	-194	-203	-213	-224
NET PR VAL LF.	-1382																				

AMERICAN SANDA RESOURCE RECOVERY ASSUMPTION CASE 9

PLANT CAPACITY (TPD)	100.00
OPERATION (TPD)	100.00
CONST COST YR (\$000)	17230.00
ANNUAL OUTPUT (MILLIONS KWH)	11.49
REV RATE ELECT YR 0 (\$/KWH)	0.13
ANNUAL OUTPUT (MILLIONS LBS STEAM)	0.10
REV RATE STEAM YR 0 (\$/1000LBS)	0.60
FINANCING FEES (ZREED FINANCED FUNDS)	0.60
FINANCING PROCEEDS (\$000)	0.60
EQUITY CONTRIBUTION (CONST COST)	0.60
EQUITY CONTRIBUTION (\$000)	0.60
TOTAL RECD CAPITAL	0.60
RECD DEBT COVERAGE FACTOR	0.60
TERM (YRS)	0.60
OPERATION COST YR 0 (\$000)	864.00
MAINT COST YR 0 (\$000)	141.00
INS COST YR 0 (\$000)	64.00
RESIDUE DISP COST YR 0 (\$000)	29.00
LANDFILL COST YR 0 (\$000)	73.00
DISCOUNT FACTOR	0.47
ELECT ESCAL FACTOR	0.47
OPER MAINT ESCAL FACTOR	0.45
LANDFILL ESCAL FACTOR	0.45
COST OF BORROWED FUNDS	0.10
MAINT FUND YR 0 (\$000)	86.00
LANDFILL TIP FEE YR 0	2.20