SECTION 7
EVALUATION OF SHORT-LISTED TECHNOLOGIES

7.1 GENERAL
This section contains a technical and economic evaluation of the short-listed alternatives described in Section 6.

7.2 APPLICATION TO THE EXISTING SYSTEM
Application of the new system within the existing City refuse management system is shown in **Figures 6-1, 6-4 and 6-7**. A brief discussion of the impact of each alternative is presented below:

7.2.1 Plasma Generating Station
Implementation of the plasma generating station alternative will impact the current operations at the City's transfer stations and the convenience centers only to the extent that more effort may be needed to prevent disposal of scrap metal. The refuse trucks from these centers and other sources would be diverted to the site where the generation station is located. Landfill operations at Waimanalo Gulch would be reduced significantly.

7.2.2 Metal Recycling Plant
The size of the operations at the transfer stations and the Waimanalo Gulch Landfill would have to be increased to separate scrap metal.

7.2.3 Gypsum Recycling Plant
The impact of the gypsum-recycling alternative on existing operations are the same as the metal recycling plant. The only difference is that the gypsum recycling plant alternative will not require placing containers at the convenience centers.

7.3 EXISTING SYSTEM CHANGES REQUIRED
The changes that would be needed to the existing City refuse management system to use the new system alternatives are as follows:

7.3.1 Plasma Generating Station

Key changes required to implement the plasma generating station alternative are:

- Provide additional space and add scrap metals recycling containers at the transfer station. Increase operating staff and add magnetic lifting rigs to remove scrap metals from incoming refuse.

- Reduce the size of the landfill operations at Waimanalo Gulch to process only ash from H-POWER (approximately 108,000 tons per year) and the non-recyclable material from the plasma generating station (approximately 30,000 tons/yr).

7.3.2 Metal Recycling Plant

Key changes required to implement the metal recycling plant alternative are:

- Provide additional space and add scrap metals recycling containers at the Waimanalo Gulch Landfill. Increase landfill operating staff and add magnetic lifting rigs to remove scrap metal from incoming refuse.

- Provide additional space and add scrap metals recycling containers at the transfer station. Increase transfer station operating staff and add magnetic lifting rigs to remove scrap metals from incoming refuse.

7.3.3 Gypsum Recycling Plant

Key changes required to implement the gypsum recycling plant alternative are:

- Provide additional space and add scrap metals recycling containers at the transfer station. Increase transfer station operating staff and add magnetic lifting rigs to remove scrap metals from incoming refuse.

- Provide additional space and add scrap metals recycling containers at the Waimanalo Gulch Landfill. Increase landfill operating staff and add magnetic lifting rigs to remove scrap metals from incoming refuse.

7.4 PROJECT DEVELOPMENT ACTIVITIES AND ESTIMATED DURATION

The following key activities would be required if the options identified in this report are developed, financed and owned by the private sector.

- **Feasibility Study.** A feasibility study that is focused on the selected alternative. The feasibility study to include a conceptual design, cost estimate and economic data, detailed marketing research, and an overall strategy for implementing the option is needed for all considered alternatives. The study must clearly identify the salient features of the alternative to gain a wide interest from private sector investment groups.

- **Site Selection.** Based on the information provided by the feasibility study, a review must be conducted to identify locations for the proposed plant.

- **Soliciting Expression of Interest.** Soliciting expression of interest from the private sector is useful before issuing a detailed procurement package. This interim step would ensure that a procurement process takes into consideration the concerns of the potential investors.

- **Procurement.** If reliable and credible parties are identified during the expression-of-interest process, then a bid package can be prepared. The bid package would use the information gathered during the feasibility study and the expression-of-interest process. The procurement phase will also include proposal review and the project award.

- **Environmental Assessment.** The project would require an environmental assessment according to the State's Hawaii Revised Statutes, Chapter 343, process.

- **Facility Acquisition.** Facility acquisition activities include design, permitting, construction and start-up.

Estimated schedules for implementing each of the alternatives are shown in **Table 7-1.**

Table 7-1. Activities and Estimated Duration for Acquiring Alternative Refuse Diversion Facilities.

Activity	Activity Duration (Months)		
	Plasma Generating Station	**Metal Recycling Plant**	**Gypsum Recycling Plant**
Decision To Proceed	3	3	3
Focused Feasibility Study	9	6	6
Site Selection	6	3	3
Soliciting Expression of Interest	4	2	2
Procurement	6	3	3
Environmental Assessment	18	3	3
Facility Acquisition (design, permitting & construction)	24	12	12
Total	70	32	32

7.5 MILESTONES

There are two key milestones in the decision-making process the alternatives. These are described below.

- **Go/No-Go Decision.** The first milestone is the decision to pursue one or more of the alternatives considered by this study. This decision would entail funding allocation by the City for the feasibility study, site selection, and expression-of-interest solicitation. These activities are described above.

- **Funding Source.** The second milestone, to be pursued after the conclusion of the expression-of-interest phase, is the financing decision. If no interested private investor is found, the City must develop a strategy for public funding.

7.6 PRIOR EXPERIENCE

A discussion of the experience gained by the communities using the technologies embedded in the alternatives is presented below.

7.6.1 Plasma Generating Station

The heart of the process is a plasma arc gasification and vitrification system being marketed by Integrated Environmental Technologies, LLC (IET). Several other vendors also provide electric arc melters similar to that used in this alternative. A literature search by this study pointed to several municipal refuse thermal-processing units using melting and gasification technologies (1998 and 1999 IT3 Conference Proceedings). A majority of applications are in Japan and European countries. Detailed information on their operational experience and economical viability was not readily available. Acquisition of such information will require a first-hand examination of data from the operating facilities. A summary of three prior experiences in the US is presented below:

- **Integrated Environmental Technologies, LLC, (Contact Mr. Jeff Surma at 509/946-5700).** Battelle Memorial Institute developed this technology and tested it at the Department of Energy site in Hanford, Washington. Battelle licensed this technology to IET. A 10-ton per day engineering scale DC arc plasma system, referred to as PEM™, has been constructed and is available for demonstration. This unit has been used to process a variety of waste streams such as tires, solid waste, sludge, and hazardous wastes.

- **FMC Corporation, Pocatello, Idaho**. Three full-scale electrical arc melter systems that are generally similar to the IET's unit have been used by FMC since the mid-1970s. The units receive ores containing phosphorus compounds. They melt the ore to recover elemental phosphorous from the gaseous waste stream. The remaining soil in the ore is discharged from the furnace as a molten slag. The molten slag is cooled and is either sent to a storage pile or used as a granular media for road construction.

- **Allied Technology Group (ATG) GASVIT™ (Contact Bob Julian, Washington State Department of Ecology 509/736-5702).** IET has sold a 10-ton per day plasma arc gasification/vitrification unit to ATG. This unit is trademarked by ATG under the name of GASVIT™. This system has received an extensive risk assessment and evaluation by the Washington State Department of Ecology and the US-EPA Region 10 for processing

toxic wastes. The unit has received a RCRA/TSCA Part B permit and the full-scale commercial operation is expected by early 2000.

7.6.2 Metal Recycling Plant

Metal recycling is a common technology and is employed by industrial facilities generating scrap metal and many municipal refuse systems. There is no technical risk in this technology as it has been in existence for several decades. The environmental aspects of this technology are also well known.

7.6.3 Gypsum Recycling Plant

Gypsum recycling is an innovative new use of commonly available machinery for pulverization of scrap gypsum and separation of the facing paper. The major barrier is that the market in which a recycled gypsum can be sold is new and in the developmental stage. In order to pursue a gypsum recycling option, the City must first undertake a market development program for recycled gypsum in the Hawaii Islands. A literature survey indicates that a minimum of two plants are practicing gypsum recycling in the US. Operational and economical experience at one of these firms is summarized below.

- **Construction Debris Recycling Inc. (Contact Ben Gordon, 518/271-4491).** The CDR facility opened in early 1999 near Albany, NY. The facility accepts drywall and roofing shingles. Gypsum is being processed into agricultural soil additives, construction material, manufacturing ingredients and odor and spill control material. It can be used to compensate for heavy clay soil and soil that is deficient in calcium and sulfur. When added to compost, gypsum can help the retention of nitrogen. Gypsum is also mixed with sand and used as animal bedding in horse stables. Gypsum absorbs urine odors and neutralizes and boosts nitrogen in the field. Paper separated from gypsum can also be used as animal bedding to absorb odor. C&D experience indicates that gypsum must be manually separated from other construction debris and that the current mechanical sorting technologies have not been effective in this application. CDRs primary revenue stream is from tipping fees. CDR experience indicates that a tipping fee of $45 to $50 would be needed to break even.

7.7 PERMITTING

Air emissions, water discharge and land disposal permitting requirements of the alternatives were reviewed. A State of Hawaii, Department of Health, solid waste permit will be required for all alternatives. Residual disposal of solid waste should be covered by existing permits.

The plasma generating station would require both air emissions and water discharge permits. The more significant of the two, the air emission permit, must be obtained for the turbine generators. Such a permit is expected to be routine and without any significant permitting issues. The plasma system would also need a water discharge permit for wastewater generated from the syngas cleaning scrubbers.

The metal recycling and gypsum recycling plants are expected to require only air emissions permit for the dust collector exhaust streams.

Environmental impact assessments would also be required for the alternatives. At this point, it is judged that the metal and gypsum recycling plants would require only an environmental assessment. However, due to its large size and potentially significant impact, the plasma generating station alternative is expected to require a full environmental impact statement.

7.8 OPERATIONAL RELIABILITY

7.8.1 Plasma Generating Station

The heart of this alternative is the plasma system. The durability and life of this system is comparable to a standard electrical arc furnace. This type of furnace is widely used in the mining and metal industry. For example, three large electrode arc furnaces have been operated at the FMC elemental phosphorous plant in Pocatello, Idaho, since the mid-1970s. The plasma process chamber is judged to have no reliability problem because it will use the latest refractory and product discharge mechanisms that have been tested at a smaller scale, but there is no operational experience at the project scale to support this. Some of the system auxiliary components, such as refuse feeders, process feed controls and syngas processing units, will require large scale application and long-term operational results so that their reliability in a refuse processing environment can be established.

7.8.2 Metal Recycling Plant

The heart of this plant is the separation and shredding equipment. These components are high maintenance but can be operated in a reliable manner by instituting a preventative maintenance program.

7.8.3 Gypsum Recycling Plant

The heart of this plant is the device that separates paper facing from wallboards. Proper operation of this equipment will require that the scrap gypsum be dried before it is fed to the crushers. As stated before, these components are high maintenance items that can be operated in a reliable manner by instituting a preventative maintenance program.

7.9 IMPLEMENTATION BARRIERS AND INCENTIVES

Factors that would provide significant incentives and barriers for implementing the alternatives are discussed below:

7.9.1 Plasma Generating Station

The incentives for implementing this alternative are: 1) Much of the refuse stream to Waimanalo Gulch is diverted; 2) the thermal process is environmentally friendly (i.e., nearly eliminates dioxin/furans in the thermal unit exhaust, the final residue is a vitrified rock/glass); 3) the process generates syngas which can be used in conjunction with a high efficiency (30%) turbine generator; and 4) the electricity produced by the facility is in high demand.

Impediments for this alternative are: 1) high economic risk because the viability has not been proven, and 2) high technical risk because the technology is first-of-a-kind.

7.9.2 Metal Recycling Plant

Incentives for this option are: 1) the technology and economics are well known; 2) scrap metal market is a well established; and 3) a relatively low level of capital investment, hence, attractive to private sector investment.

Impediments are: 1) The scrap metal price fluctuations increase the investment risk; 2) the costs for offshore shipment may be prohibitively high; and 3) the alternative addresses only a small portion (11%) of the Waimanalo Gulch refuse stream.

7.9.3 Gypsum Recycling Plant

Incentives for implementing this option are: 1) the technology has been used in the past and 2) the capital investment is relatively low, hence, attractive to private investors.

Impediments are: 1) the recycled gypsum market and prices are in a developmental stage and, hence, the economic risks are relatively high; 2) the alternative addresses only a small portion (7%) of the Waimanalo Gulch refuse stream; and 3) the experience with the technology is short-term (since early 1999).

7.10 DIVERSION CAPABILITY

The plasma generating station offers the highest diversion potential. The alternative could divert a major portion of the waste currently being sent to Waimanalo Gulch. It is expected that 10% of the waste would have to be sent to the landfill.

The metal and gypsum recycling plants will divert approximately 11% and 7%, respectively, of the material going to the Waimanalo Gulch Landfill.

7.11 ECONOMIC FEASIBILITY

The revenue and expense estimates for the alternatives are shown in **Table 7-2.** Expenses incurred are the annual facility cost of capital, O&M costs, if any, and the cost of disposing waste from the facilities. The revenues include tipping fees and the sale of any recyclable product produced by the facility.

The capital cost is amortized over a 20-year period assuming the required capital will be raised through a tax-free industrial revenue bond (IRB). The assumed interest rate for the IRB is 7% per annum. The resultant annuity incurred by the facility cost of capital is $94,390 for each one million dollar of facility capital cost.

For all options, the facility tipping fees are assumed to be equal to the current refuse disposal rate ($72.25 per ton of waste) at Waimanalo Gulch. The electricity is assumed to be sold at a price of $0.08 per kwh. The recycled scrap gypsum and scrap metal are assumed to be sold at $50 per ton.

The results of the economic analysis is presented below:

7.11.1 Plasma Generating Station

As shown in **Table 7-2**, the cost of facility operations is $119.50 per ton of refuse received at the facility. The income from the facility is $91.31 per ton of refuse received at the facility. The net result is a negative $28 per ton of waste processed at the facility. Hence, the facility is not

anticipated to generate positive cash flow under the City's current economic evaluation conditions.

7.11.2 Metal Recycling Plant

As shown in **Table 7-2,** the facility annual expense is $115.76 per ton of refuse received at the facility. The annual income from the facility is $87.12 per ton of refuse received at the facility. The net result is a negative $29 per ton of waste processed at the facility. Hence, the facility is not anticipated to generate positive cash flow at the current City economic evaluation conditions.

7.11.3 Gypsum Recycling Plant

As shown in **Table 7-2,** the facility annual expense is $129.03 per ton of refuse received at the facility. The annual income from the facility is $90.25 per ton of refuse received at the facility. The net result is a negative $39 per ton of waste processed at the facility. As a result, this facility also is not anticipated to generate positive cash flow at the current economic criteria that are established for evaluating the alternatives.

Table 7-2. Estimated Expense and Income for the Alternatives.

Line No.	Description	Plasma Generating Station	Metal Recycling Plant	Gypsum Recycling Plant
	Refuse Processed (Tons/Yr)	278000	41700	20000
	Non Recyclable Refuse Returned for Landfill (Tons/Yr)	52000	10700	2000
	Recyclable Material For Sale (Tons/Yr)	31000	31000	18000
	Electricity For Sale (MWH/Yr)	58500	0	0
100	**Annual Expense**			
101	Facility O&M	$14,803,719	$2,818,688	$1,663,569
102	Facility Capital Cost (20 years @ 7% APR)	$14,660,945	$1,110,511	$712,607
103	Annual Cost for Disposal of Returned Refuse (@$72.25/Ton)	$3,757,000	$773,075	$144,500
104	Additional Cost Imposed on Existing Refuse System ($/Yr)	$0	$125,100	$60,000
105	**Subtotal**	$33,221,663	$4,827,374	$2,580,676
106	**Cost Per ton**	**$119.50**	**$115.76**	**$129.03**
200	**Annual Revenue**			
201	Tipping Fee (@$72.25 per ton)	$20,085,500	$3,012,825	$1,445,000
202	Sale of Recycled Product (@20/ton)	$620,000	$620,000	$360,000
203	Sale of Electricity (@ $0.08/kwh)	$4,680,000	$0	$0
205	**Subtotal**	**$25,385,500**	**$3,632,825**	**$1,805,000**
206	**Revenue Per Ton**	**$91.31**	**$87.12**	**$90.25**
301	**Gross Profit (Loss) Per Ton**	**($28)**	**($29)**	**($39)**