

Improving Urban Waste Management and Generating Renewable Electricity Using the EnviroCycler Gasification Technology in the Philippines¹

Main Stakeholders

- Hawaii Pacific Energy Group of Honolulu, Hawaii (HPEG) and Access Energy Technologies Ltd. (AET) of Vancouver, Canada: sole global licensee of the “EnviroCycler” gasification technology, as a means to produce substantial energy from a renewable biomass feedstock, particularly municipal solid waste (MSW);
- Cities and municipalities that need effective solutions for better managing the growing solid waste problems in their communities that often leads to the exacerbation of flooding, increase of disease, pollution of surface and ground water resources and the general degradation of the physical and socio-economic environments, particularly in the vicinity of landfills; and
- Cities and communities suffering from a chronic shortage of electricity, whereby the EnviroCycler technology will provide increased energy security through electricity generation using MSW as a renewable energy resource while at the same time reducing greenhouse gas emissions and the need to import fossil fuels as well as provide sustainable employment.

Current Waste Management and Energy Generation in Emerging Economies Such as the Philippines

In a world where issues of global warming, energy security and deteriorating urban environments are dominant in many countries, particularly in the emerging economies, the EnviroCycler technology is a proven technology that can significantly address these issues anywhere in the world. The benefits of this technology include the reduction of greenhouse gas emissions, elimination of the need for costly and environmentally damaging landfill practices, production of commercial energy using the organic fraction of municipal solid waste (MSW) and other waste streams, making significant improvements to urban and rural environments, reducing reliance on expensive imported fossil fuels, and creating employment.

Current methods of managing municipal solid waste (MSW) generated by households and commercial enterprises, construction debris, wastewater treatment and medical waste in the Philippines often is landfilling in both engineered sanitary landfills and, very often, in ad hoc, informal landfills or dumps, particularly in developing countries. Often the landfills are improperly designed, are illegal, or are operated not as sanitary landfills and with little or no management and controls. In many cases, waste in the urban setting of many communities is not managed at all, particularly in areas of informal settlements.

Waste from these informal communities easily and quickly ends up in waterways, drains, canals, and streams and rivers, thus polluting the waterways and exacerbating severe flood events, which annually cause death and destruction, and substantially increasing the incidence of disease, costing the national economy very dearly in terms of money, damaged lives and property, a degraded environment full of waste plastics, and lost opportunities.

For instance, as Cambodia, Indonesia, Laos, the Philippines, Thailand, and Vietnam have become emerging economies so quickly has the increase of growth in the migration of people from rural to urban areas, thereby rapidly increasing the problem of appropriate urban waste management, which in reality is actual waste mismanagement. Pressure to provide land for settlement in and near these urban centres means there is increasing difficulty in identifying suitable landfill sites, thereby making landfills an inappropriate solution for

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managing urban waste. Moreover, landfills generate methane, which is a potent greenhouse gas exacerbating to climate change.

At the same time, growing economies and the relentless migration of people to urban areas results in a rapidly increasing demand for electrical power. Management of this increased demand in emerging economies is often difficult and limited because of insufficient non-renewable energy resources, increasing costs of physical plant, and fossil fuels, which are impacted by global, external factors often beyond the control of the city or communities experiencing electrical shortages. With electricity demands of emerging economies being met through imported diesel and natural gas fuel, the cost of electricity has steadily risen with the rising global costs of fossil fuels. The use of fossil fuels also generates a less visible cost in the form of increased emissions and the generation of greenhouse gases that lead to climate change, increased ground-level ozone, and a degraded urban environment that generates its own set of costs arising from having to deal with related health issues and reduced productivity of the urban population.

At the macro-economic level, Southeast Asian countries are seeking to reduce their dependence on imported fossil fuels and their exposure to rising global prices for fossil fuels such as those experienced in 2008. MSW is viewed as a source of domestic renewable energy that can curtail the demand for these imported fuels. Mass incineration of MSW-to-energy plants such as those provided by the likes of Veolia, Suez, Covanta, Hitachi Zosen Inova, and China Everbright International are extremely expensive in terms of capital costs and operating costs, and must also be co-fired with an external fossil fuels, typically natural gas.

HPEG's patented EnvirOcyler technology can address these two growing urban problems of growing municipal solid waste and decreasing supply of electricity in a single package by converting MSW to energy through a process that is viable and clean, with low emissions, using a two-stage reduction/thermal oxidizing unit that generates up to 105 GJ/hour per unit from any wet biomass such as MSW without any co-firing with an external fuel source.

Technology Brief of the "EnvirOcyler"

HPEG will make available its patented EnvirOcyler technology for the conversion of waste streams including the organic fraction of municipal solid waste (MSW) into oxidative gases and heat that can be used for electrical power generation or, alternatively, industrial process heat. The EnvirOcyler, a Canadian technology, is a 2-stage reduction gasification/thermal oxidizer (GTO) that:

- reduces wet biomass in its large first stage of (gentle and updraft) gasification powered by the MSW itself (no external co-firing fuel required); and
- immediately oxidizes the first stage "producer gas" in a second stage of vigorous, double vortex, cyclonic, thermal oxidation, the heat from which can be used to generate electricity or used directly for industrial processes.

The EnvirOcyler is believed to be the cleanest wet biomass reduction gasifier/thermal oxidizer available today with minimal emissions.

The EnvirOcyler's versatile two-stage (reduction gasification/thermal oxidation) structure creates producer gas from wet biomass through gentle updraft gasification in the first stage followed by a thermal oxidization process (ignition and combustion) of the producer gas under vigorous cyclonic conditions to ensure complete combustion in a second stage. The 1010°C (1,850°F) products of combustion from a 105 GJ/h (100 million Btu/h) EnvirOcyler are routed to a waste heat recovery unit that can be used to produce steam for a condensing steam turbine electricity generating set or, alternatively, heat transfer fluids for an organic Rankine cycle turbine generator.

Net power supplied to the electricity grid by a single 105 GJ/h EnviroCycler unit is approximately 5.5 MWe. Compared to other gasification technologies, the EnviroCycler's parasitic load for operating the plant is minimal, thus making it an efficient means to generate electricity. The versatility of the EnviroCycler allows it to be operated in tropical or temperate climates provided the moisture content of the biomass is between 35% and 60%.

A 105 GJ/h EnviroCycler could utilize the following MSW loads as fuel. For example:

- 287 tonnes/day of MSW at 35% moisture content; or
- 358 tonnes/day of MSW at 45% moisture content; or
- 476 tonnes/day of MSW at 55% moisture content.

The need for a minimum of 35% moisture content means that energy from the process does not need to be parasitized for drying the waste prior to processing, as is required in other gasification technologies on the market, meaning more energy is available for generating electricity, thereby resulting in a higher output efficiency.

Assuming an average of 1.5 kg of MSW generated per capita, a single EnviroCycler unit can convert the organic fraction of municipal solid waste into heat for communities ranging in population size from 184,000 to 305,000.

A schematic of the EnviroCycler is shown in Figure 1.

The EnviroCycler is the cleanest wet biomass gasifier/thermal oxidizer currently available in the market. HPEG/AET has been granted full and exclusive license rights for the EnviroCycler. Two EnviroCyclers are in operation in Solway, Minnesota, USA and another two in Bahau, Malaysia selling electricity to the Malaysian grid from a generation capacity of over 10.5 MW while also generating revenue in the form of carbon credits from CDM. The Malaysian plant is shown on Figures 3 and 4.

The EnviroCycler was originally developed in British Columbia, Canada in the late 1970s and is a proven technology that has been in continuous operation for over 35 years. Recent innovations, driven by the need for using MSW as a feedstock for the EnviroCycler, have been made to bring the system up to current standards including improvements to the mechanics of the system, automating the ash removal system, changing the first stage trash grate from flat to an "A" frame, and updating the control logic. These innovations have been made to increase efficiency and output, but without affecting the process.

These innovations have been made to increase the EnviroCycler's efficiency without affecting the process. The 1010°C (1,850°F) products of combustion from the 105 GJ/h (or 100 million BTU/hr) EnviroCycler can be routed to a waste heat boiler, the steam from which can be used for industrial purposes (i.e. making steam) or to drive a condensing steam turbine generator set to make electricity. Emissions from the EnviroCycler meet the most stringent emission standards including the US EPA². This is based on the EnviroCycler's robust design that ensures high-temperature oxidation of the producer gases is complete. This is evidenced by the fact that emission readings of carbon monoxide (CO) emissions from the EnviroCycler are almost nil. Figure 4 is a schematic of a typical EnviroCycler plant with power generation facilities.

² This includes < 1 ppm for CO, 15 ppm for NO_x, < 100 mg/m³ for particulate matter, no traceable toxins. Further emissions reductions, if necessary, can be realized with the addition of a selective catalytic reactor to eliminate NO_x by converting it to N₂ and O₂, and a "bag house" to capture particulate matter.;

Comparative Advantages of the EnvirOcyclor Technology

Competing gasifiers use updraft, downdraft, plasma, fluidized bed, mass incineration or aerobic digestion technologies. Regardless of the specific technology details, several fundamental differences in approach distinguish the EnvirOcyclor from competitors' products:

- Other systems strive to create a synthetic gas to fuel some sort of separate engine. This requires supplementary cleaning up of the producer gas and gas handling systems that require using external energy and cause complications in the engines. EnvirOcyclor gasifiers are pure heat machines that supply heat for direct use or to drive an electricity generating turbine cycle;
- Other systems must use carefully controlled feedstock with small particle sizes and low moisture content to sustain their reactions. This requires elaborate and expensive feedstock screening, pre-treatment, and sometimes drying equipment that may use external energy or significantly parasitize produced energy. The EnvirOcyclor gasifier accepts waste streams with particles sizes from 6 mm ($\frac{1}{4}$ inch) to 100 mm (4 inch) and with a moisture content of 35% to 60%, provided it has been screened to remove metals, recyclable plastics, and non-combustible materials. It uses the waste stream itself to provide energy for the gasification process so no external co-firing using fossil fuel is required;
- Other systems consume fuel very quickly (in the order of seconds at most) to sustain their reactions. This leaves almost no time to adjust to differences in electricity or fuel demand or fuel composition. The EnvirOcyclor has a fuel residence time of about an hour, a lower first stage burner temperature of 650°C (to avoid vaporizing sodium and chlorides that precipitate on the walls of the gasifier and the ash grate) and can accommodate 15-second step changes in demand, allowing plenty of time to adjust for differences in fuel composition. The consequence of the slower reaction rate of the EnvirOcyclor is that it tends to be much larger than other machines of equivalent energy output;
- The conversion of MSW to energy by the EnvirOcyclor is highly efficient in comparison to other technologies. The parasitic load or the proportion of energy used by the MSWTE plant to power its operations is in the order of only 16%. We understand plasma uses upwards of 40% of its own electricity generating capacity to power the plasma flame that converts the MSW to heat.

Gasification/Thermo-Oxidation Compared to Mass Incineration

Mass burn incineration is the most common method deployed to convert MSW into energy. It is a one-step, high temperature, highly oxidizing environment with almost continuous and costly external fossil fuel support. Emissions of a mass burn incinerator are dioxins, furans, PCBs, NO_x, potentially unburned tar and volatile organic carbons that produce obnoxious odors and smoke that can create health issues in the community. To meet stringent emission standards, many of these plants are outfitted with extensive pollution controls that consume a significant amount of the energy produced by the plant.

The gasification/thermo-oxidation (GTO) process in the EnvirOcyclor is an order of magnitude improvement over mass burn incineration. GTO is a two-step, controlled oxidation environment without the need for any additional supplementary fuel following initial start-up. The carbon conversion to producer gas is carried out in an oxygen-starved environment at about 75% of stoichiometric requirement. This producer gas is then completely oxidized using excess air in a second, highly turbulent double vortex chamber. Carbon conversion ratios within the GTO process of the EnvirOcyclor are over 99% compared to the 70% to 80% for mass burn incineration plants. The GTO process using the EnvirOcyclor will completely combust all organic compounds with little or no particulate matter and other air pollutants, all while being able to accept varying feedstock moisture from 30% to 65% moisture content. This is the distinct advantage of GTO and the EnvirOcyclor in comparison with other MSWTE systems on the market.

Detailed Description of the EnviroCycler Process

The EnviroCycler is a two-stage gasification unit that converts wet biomass (such as wood waste or MSW) into a combustible “producer gas” in its very large, first stage chamber of gentle, updraft gasification and subsequent conversion of this gas into heat through vigorous, double vortex thermal oxidation in its second stage. Components and processes on an EnviroCycler project as illustrated in Figure 2 include:

- A Material Recycling Facility (MRF) that converts MSW into RDF (Refuse-Derived Fuel) to ensure that the EnviroCycler feedstock is the organic fraction and is less than 150 mm (for a 100 MMBTU unit) and 75 mm (for a 30 MMBTU unit) sizes. State of the art separation equipment or local labour will sort, size and remove ferrous and non-ferrous metals, plastics, glass, and paper for recycling for added revenue, whenever economically feasible, although paper can also be used for feedstock;
- A refuse storage facility to store MSW or other types of feedstock;
- A fuel-feed conveyor and mechanically operated fuel metering bin to feed MSW from the refuse storage facility into the EnviroCycler gasifier/thermo-oxidizer;
- The EnviroCycler gasifier/thermo-oxidizer that converts MSW into energy. In its first stage, MSW is gasified in an oxygen-starved atmosphere using a combination of primary, secondary and tertiary combustion air with damper-controlled fan banks. The resulting producer gas then rises to the second stage where it is completely oxidized in a refractory-lined secondary oxidization chamber at 1010°C;
- A refractory lined duct retains the products of combustion through a one-second residence time to ensure complete combustion before the hot products of combustion enter the heat recovery steam generator (HRSG);
- Pollution controls will ensure EnviroCycler emissions meet the most stringent emission standards prior to their release into the atmosphere. Pollution controls could include a bag house for particulate matter, multi-cyclone, selective catalytic reduction unit (SCR), activated carbon injection (ACI), and dry electrostatic precipitator (ESP);
- A heat recovery steam generator recovers the 1010°C products of combustion. This would be a waste heat boiler to produce steam;
- High pressure steam can then be converted to electricity by passing through a steam turbine driving an electricity generator. The products of combustion from one 105 GJ/hr EnviroCycler will result in the generation of 6.5 MWe of green electric power; or
- Alternatively, where there is low water availability, the products of combustion can be transferred to an Organic Rankine Cycle (ORC) turbine using a thermal transfer fluid³.

³ This can be thermal oil that vaporizes a silicon fluid (via heat exchanger), which in turn drives the turbine. The ORC system is completely self contained and closed loop, requiring no additional makeup water or chemicals. Unlike conventional steam turbine generation which requires a First Class Power Engineer, the thermal oil/ORC system is classified as a 3rd or 4th class plant, requiring only a 3rd or 4th class Power Engineer

EnvirOcyler Control Logic

Control of the thermal process is of the highest importance when establishing waste-to-energy projects. The EnvirOcyler is equipped with an advanced level of integrated control technology providing continuous conformance within set conditions and permitting compliance.

The control logic system installed on the EnvirOcyler has a sensor suite consisting of multiple data acquisition points throughout the entire process, giving the plant controller detailed and highly accurate measurements of the system's performance. These measurements allow the operator to effectively fine tune system performance and respond immediately to demand changes received by the EnvirOcyler. Control parameters are pre-programmed to notify plant operations personnel if any set conditions are approaching the boundary of normal operating parameters, allowing response without delay to correct any condition before it becomes a boundary event.

EnvirOcyler Emissions

Compared to other waste-to-energy systems, the EnvirOcyler produces minimal emissions, therefore it does not require expensive downstream flue gas treatment technologies. The low CO emission indicates complete combustion, attributable to the EnvirOcyler's double vortex combustion chamber.

The low NO_x, basically "fuel" NO_x from nitrogen in the fuel indicates the efficacy of the low temperature and "staged combustion" employed in the EnvirOcyler. The EnvirOcyler discharge temperature is too low to generate "thermal" NO_x. Much higher levels of NO_x (50 to 150 ppmv) are common when burning fossil fuels and therefore are also generated in mass incineration plants. These higher NO_x levels of "thermal" NO_x are due to combustion temperatures typically in the 1400°C to 1500°C range. At such temperatures, the nitrogen in the combustion air (4 parts by weight of nitrogen are brought in with each part of oxygen) dissociates and readily combines with oxygen to form NO_x. It also reacts with VOCs (volatile organic compounds) such as automobile exhaust, and forms ground level ozone. The EnvirOcyler avoids such emissions and their environmental impacts.

Similarly, in 1978, particulate tests on an earlier unit disposing of typical sawmill residue yielded 102 mg/Nm³, or 0.04 grains/dscf, of particulate straight out of the unit's stack. This translates into an EPA source emission factor of about 0.12 lb/MM Btu for particulate. It is important to note that the EnvirOcyler's products of combustion are, typically, routed through waste-heat boilers or waste-heat heat exchangers. In so doing, the sensible heat extracted from the products of combustion lowers the waste-heat device's stack temperature down to, typically, 177°C. A bag house can then be used to lower the amount of particulate released to atmosphere by a factor of 5, or down to 0.01 grains/dscf, 20 mg/Nm³ or 0.02 lb/MM Btu.

Dioxins and Furans

Dioxins form when chlorine atoms from natural biomass, PVC (polyvinyl chloride), and other plastics dislodge hydrogen atoms along the cellulose molecule and take their place. In the furnace of a typical utility boiler or mass incinerator, MSW burns on a grate at the bottom of the "black" (from a radiation perspective) waterwall-lined furnace. The intermediate products of combustion of the MSW waft from the grate through the "black" waterwall-lined cavernous furnace of the boiler. As they do so, their temperature drops drastically due to radiant heat transfer to the waterwalls. The result is the "locked in" replacement of the hydrogen atoms with the chlorine atoms on the intermediate products of combustion that eventually rise to the boiler stack.

Any dioxins or furans that might have formed in the EnvirOcyler's first stage are completely consumed in the EnvirOcyler's second stage of vigorous, cyclonic combustion. No black waterwalls, as in the mass incineration

WTE plants, are present to chill the reactions taking place in its inner vortex of flaming gases. The second stage is also lined with hot, glowing refractory material, where no dioxins or furans can be formed.

In 2002, an evaluation of the EnvirOcyler technology for SNC-Lavalin was completed for a proposed EnvirOcyler facility in Brackendale, BC, Canada. The analysis based its findings on its work repeating screening-level dispersion modeling analysis performed by the BC Ministry of Water Land and Air Protection (MWLAP), and assumed a high efficiency baghouse filtration system to significantly reduce secondary particulate emissions (PM) from the plant. The evaluation concluded that there would be significant reduction of PM from the current landfill practices of open burning of demolition wood waste. In addition, the evaluation concluded that carbon monoxide (CO), nitrous oxides (NO_x) and volatile organic compounds (VOCs) would be very low due to the gasification and staged combustion design, and the high combustion efficiency of the EnvirOcyler.

EnvirOcyler Outputs

Heat

A single EnvirOcyler produces up to 105 GJ/hr of energy. More units can be added on site for higher power generation and a higher rate of MSW disposal. The heat can be converted to electricity or sold directly to energy consuming facilities such as hospitals or to industrial facilities for air conditioning or process heating purposes. HPEG also has scaled-down designs of the EnvirOcyler at 63 GJ/hr and 32 GJ/hr for smaller applications and communities.

Electricity

A 105 GJ/hr EnvirOcyler unit produces 6.5 MW of gross power. Approximately 1.0 MW of parasitic power demand is required to operate the MSWTE plant, leaving 5.5 MW of net power that can be sold to an electrical utility as grid electricity.

Ash

Depending on the composition of the MSW or biomass being converted to energy, the EnvirOcyler produces ash that can be used as:

- an additive to make concrete stronger, more durable, and more resistant to chemical attack, similar to fly ash;
- a soil conditioner; or
- a liming agent for soils in agriculture.

Benefits of the EnvirOcyler to the Municipality and its Urban Setting

Adopting the EnvirOcyler technology, as an important component of a municipal waste management program, provides a number of immediate and significant benefits to a city or municipality and its citizens:

- Converts non-reusable waste as a renewable energy resource into combustible gases for electricity generation and other economic benefits while providing an environmentally-friendly solution to municipal solid waste management. EnvirOcyler feedstock can be MSW, sewage treatment sludge, construction wastes, medical wastes, garden refuse, or agricultural wastes;
- Increases local energy security by producing electricity for local supply using a renewable energy resource while generating revenue by selling electricity to the local electrical grid;

- Utilizes MSW and other high-moisture content wastes to offset the use of expensive imported fossil fuels for generating electricity and heating. A single 105 GJ EnvirOcyler unit will offset the equivalent of more than US \$10 million in imported fossil fuels each month, assuming the price of oil is at US \$100 per barrel;
- Reduces the direct production of greenhouse gases from electricity generation by offsetting the use fossil fuels;
- Eliminates the need for new landfill sites or the expansion of existing landfills to accommodate municipal solid waste streams from urban areas, therefore allowing that land to be put to more productive and better economic uses;
- Reduces the risk of soil and groundwater and surface water contamination and of the spreading of disease from landfills, particularly if the need for landfill is completely eliminated;
- Reduces the risk of rat-borne leptospirosis since the waste in urban areas would be more effectively managed and removed from the urban environment;
- Reduces environmental pollution to rivers, land, and air in jurisdictions and communities where there is a lack of regulated waste disposal and a lack of restrictions on the open burning of solid waste;
- Reduces pests and provides an improvement of community aesthetics near landfill sites;
- Improves the quality of urban and rural environments, particularly where improper MSW management contributes to flooding;
- Reduces the use of fossil fuels and concomitant production of GHG from trucks delivering MSW to distant landfill sites;
- Reduces the use of fossil fuels and concomitant production of GHG from equipment and machinery operating at landfill sites;
- Reduces significant GHG emissions (methane) generated in landfills;
- Produces a marketable byproduct in the form of fly and bottom ash that, depending on the composition of the MSW, can be sold as a soil conditioner, as a concrete strengthening and durability additive, or as a liming agent in agriculture;
- Provides added revenue from the recovery of recyclable materials from the upstream MWS stream prior to conversion into the refuse-derived fuel feedstock;
- Provides added revenues from carbon credits. An EnvirOcyler project can be registered under the United Nations clean development mechanism (CDM) to generate carbon credits for added revenue because its electricity generation offsets the equivalent quantity of carbon dioxide produced by electrical generation through the use of fossil fuels and also because managing MSW with the EnvirOcyler offsets the production of methane (a significant GHG) otherwise produced by the MSW if it were landfilled instead; and
- Creates employment opportunities for as many as 80 persons for each EnvirOcyler 105 GJ unit.

Estimated Rates of Return on Investment

Depending on the proposed site, characterization of the current MSW, and MSW management practices and other wastes derived from the community, the cost of existing fossil-fuel electricity generation, waste tipping fees, and electricity grid feed-in tariffs, the EnvirOcyler can have an estimated rate of return of as high as 14% in about 8 years. HPEG would carry out an economic evaluation of a proposed project to determine the actual rate of return, net present value, cost-benefit ratio, and payback period based on the actual physical and economic circumstances and existing MSW management practices of the project community. HPEG would also review a community's current upstream MSW practices to determine how to enhance the management of MSW so as to increase efficiencies of the overall MSW management process related to the use of the EnvirOcyler. A

more detailed economic analysis will be required to assess the available waste streams, and to re-estimate the rate of return based on the negotiated tipping fees and energy prices.

HPEG's Roles and Responsibilities

HPEG will:

- coordinate various local consulting and community teams and assist the city or municipality to develop the project; however the city or municipality would be expected to facilitate obtaining land titles, building permits, environmental permits, and any other regulatory permits within a minimum period of time;
- deliver a detailed engineering design (DED) and process for the EnvirOcyler installation;
- employ an on-site installation team to install a complete EnvirOcyler power plant and auxiliaries that would include:
 - all instruments and controls related to the operations of the EnvirOcyler;
 - the EnvirOcyler A-grate assembly and mechanisms located in the first stage;
 - all underfire, overfire and combustion fans and blowers;
 - all refractory brickwork and castings that line the second stage of the EnvirOcyler;
 - the ash handling and automatic ash removal system and storage units;
 - services related to the fabrication and on-site assembly of one EnvirOcyler unit;
 - design and installation of all ancillary structures to house and provide a continuous supply of MSW to the EnvirOcyler, including facilities for upstream separation of recyclable materials;
 - construction and assembly of electricity generating facilities that use heat derived from the EnvirOcycle; and
 - training of local personnel to operate and maintain the EnvirOcyler unit and its integration with the existing electricity system.

Installation: Proposed Schedule and Estimated Costs

HPEG's estimate of the time to install a 105 GJ/hr EnvirOcyclers and an electrical power generating station is 18 to 24 months from the time all legal and regulatory permits have been received. The estimated cost of installing an EnvirOcyler depends on many factors, which would be ascertained as part of a feasibility study after an agreement to advance an EnvirOcyler project has been reached. HPEG could assist to arrange to secure financing for the installation of the plant to be installed at a project site.

HPEG will provide the following as a minimum:

- completion of construction and shop drawings and associated engineering designs for the 100 million BTU EnvirOcyler unit;
- provide emissions tests to regulatory authorities for verification that the EnvirOcyler meets and exceeds EPA emissions standards notably for NO_x, CO, dioxins and furans;
- develop site specific drawings for a selected project at a landfill site or elsewhere, allowing HPEG consortium to develop the selected project to "shovel-ready" status;
- preparing a bankable feasibility study;
- negotiating and finalizing power purchase agreements and waste management contracts, and obtaining all regulatory approvals for the project; and
- meeting all stakeholders to ensure the proposed project is acceptable to the host community.

Upon completion of this initial stage of project development, the HPEG team will proceed with full detailed engineering, procurement, and implementation activities to complete the project within a 12-month to 18-month period. This would include training and building local capacity for operating and maintaining the WTE facility.

Possible Financing Options

HPEG would like to take an equity position on MSWTE projects through a build-own-transfer (BOT) or, alternatively, a build-own-operate (BOO) implementation modality. BOO would provide HPEG with long-term cash flows, hereby estimated at a conservative 20-year project life with zero salvage value afterwards. Based on this scenario, HPEG would obtain financing to build the units, operate them for a minimum of 20 years, and receive revenues from tipping fees for municipal waste disposal and from power purchase agreements.

Puerto Princesa, Palawan, Philippines													
Projected Annual Statement of Income				Calculation of Blended Tipping Fee									
Tons per day of various waste streams @ 50%			450	Medical waste	0.25	ton/day		\$200	per tonne	\$50			
kilowatts			5,500	Wastewater	1	ton/day		\$15	per tonne	\$15			
In Tip/Tonne			\$15	Construction	10	ton/day		\$15	per tonne	\$150			
Power tariff/kwh			\$0.18			ton/day			per tonne	\$215			
	JAN	FEB	MAR	APR	MAY	JUN	JULY	AUG	SEPT	OCT	NOV	DEC	Annual Total
POWER	\$ 677,635	\$ 612,058	\$ 655,776	\$ 677,635	\$ 655,776	\$ 655,776	\$ 677,635	\$ 677,635	\$ 655,776	\$ 677,635	\$ 655,776	\$ 677,635	\$ 7,956,749
STANDBY	1	1	1	1	1	1	1	1	1	1	1	1	\$12
ALL POWER	\$ 677,636	\$ 612,059	\$ 655,777	\$ 677,636	\$ 655,777	\$ 655,777	\$ 677,636	\$ 677,636	\$ 655,777	\$ 677,636	\$ 655,777	\$ 677,636	\$ 7,956,761
ASH	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -
CERs	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -
PAP & PLA	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -
FUEL SAVINGS	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -
TIPPING FEE	\$ 209,250	\$ 209,250	\$ 209,250	\$ 209,250	\$ 209,250	\$ 209,250	\$ 209,250	\$ 209,250	\$ 209,250	\$ 209,250	\$ 209,250	\$ 209,250	\$ 2,511,000
Net Sales	\$ 886,886	\$ 821,309	\$ 865,027	\$ 886,886	\$ 865,027	\$ 865,027	\$ 886,886	\$ 886,886	\$ 865,027	\$ 886,886	\$ 865,027	\$ 886,886	\$ 10,467,761
C.O.G.S.	\$ 87,000	\$ 87,000	\$ 87,000	\$ 87,000	\$ 87,000	\$ 87,000	\$ 87,000	\$ 87,000	\$ 87,000	\$ 87,000	\$ 87,000	\$ 87,000	\$ 1,044,000
G.P./LOSS	\$ 799,886	\$ 734,309	\$ 778,027	\$ 799,886	\$ 778,027	\$ 778,027	\$ 799,886	\$ 799,886	\$ 778,027	\$ 799,886	\$ 778,027	\$ 799,886	\$ 9,423,761
Ops Admin													
Rent:	0	0	0	0	0	0	0	0	0	0	0	0	\$ -
Equip:													
Salaries:	57,040	57,040	57,040	57,040	57,040	57,040	57,040	57,040	57,040	57,040	57,040	99,820	\$ 727,260
Payroll Tax	0	0	0	0	0	0	0	0	0	0	0	0	\$ -
Benefits	0	0	0	0	0	0	0	0	0	0	0	0	\$ -
Lease Primary	48,000	48,000	48,000	48,000	48,000	48,000	48,000	48,000	48,000	48,000	48,000	48,000	\$ 576,000
Mgmt/ops	15,000	15,000	15,000	15,000	15,000	15,000	15,000	15,000	15,000	15,000	15,000	15,000	\$ 180,000
Utilities	0	0	0	0	0	0	0	0	0	0	0	0	\$ -
Prop Ins.	0	0	0	0	0	0	0	0	0	0	0	0	\$ -
Liab Ins.	0	0	0	0	0	0	0	0	0	0	0	0	\$ -
W.C.	0	0	0	0	0	0	0	0	0	0	0	0	\$ -
Tel & Comm	500	500	500	500	500	500	500	500	500	500	500	500	\$ 6,000
Legal/Acctg	500	500	500	500	500	500	500	500	500	500	500	500	\$ 6,000
Prof/Training	0	0	0	0	0	0	0	0	0	0	0	0	\$ -
E F&F	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500	\$ 18,000
Misc.	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	\$ 12,000
Monitoring	0	0	0	0	0	0	0	0	0	0	0	0	\$ -
Permit fees	25,000	0	0	0	0	0	0	0	0	0	0	0	\$ 25,000
R&D dev.	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	\$ 120,000
Engineering	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	\$ 12,000
QC, Consult	0	0	0	0	0	0	0	0	0	0	0	0	\$ -
Office, all	3,000	350	350	350	350	350	350	350	350	350	350	350	\$ 6,850
Transport	3,000	3,000	3,000	3,000	3,000	3,000	3,000	3,000	3,000	3,000	3,000	3,000	\$ 36,000
Prop Tax	0	0	0	0	0	0	0	0	0	0	0	0	\$ -
Waste	0	0	0	0	0	0	0	0	0	0	0	0	\$ -
TOTAL EXP:	165,540	137,890	137,890	137,890	137,890	137,890	137,890	137,890	137,890	137,890	137,890	180,670	\$ 1,725,110
P/L	\$ 634,346	\$ 596,419	\$ 640,137	\$ 661,996	\$ 640,137	\$ 640,137	\$ 661,996	\$ 661,996	\$ 640,137	\$ 661,996	\$ 640,137	\$ 619,216	\$ 7,698,651
LOANS	\$200,000	\$200,000	\$200,000	\$200,000	\$200,000	\$200,000	\$200,000	\$200,000	\$200,000	\$200,000	\$200,000	\$200,000	\$2,400,000
LSCR	3.17	2.98	3.20	3.31	3.20	3.20	3.31	3.31	3.20	3.31	3.20	3.10	
PAYBACK PERIOD:	67.95 MONTHS EBITA				3.21		CAPITAL:	\$43,596,000	0.177 ROI				

Table 1: Preliminary Estimates of Annual Cash Flows and Rate of Return

Figure 1: Schematic of EnvirOcyclcr

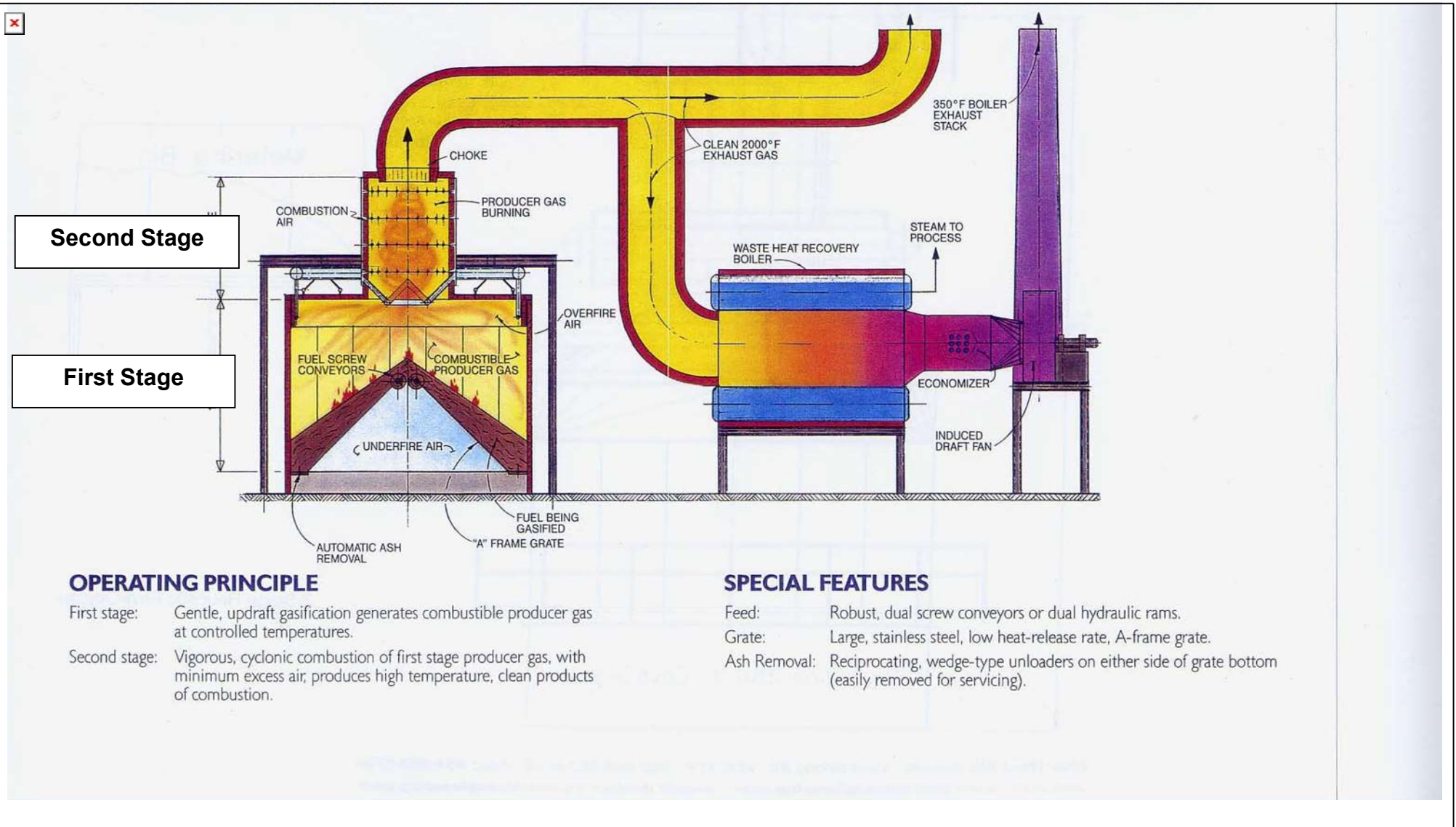


Figure 2: Existing EnvirOcyclers Plant in Malaysia (2 units producing 5.5 MW_{net} each)



Figure 3: 105 GJ EnvirOcyclers Unit in Malaysia



Figure 4: Typical EnvirOcyclor Waste-to-Energy Plant Layout

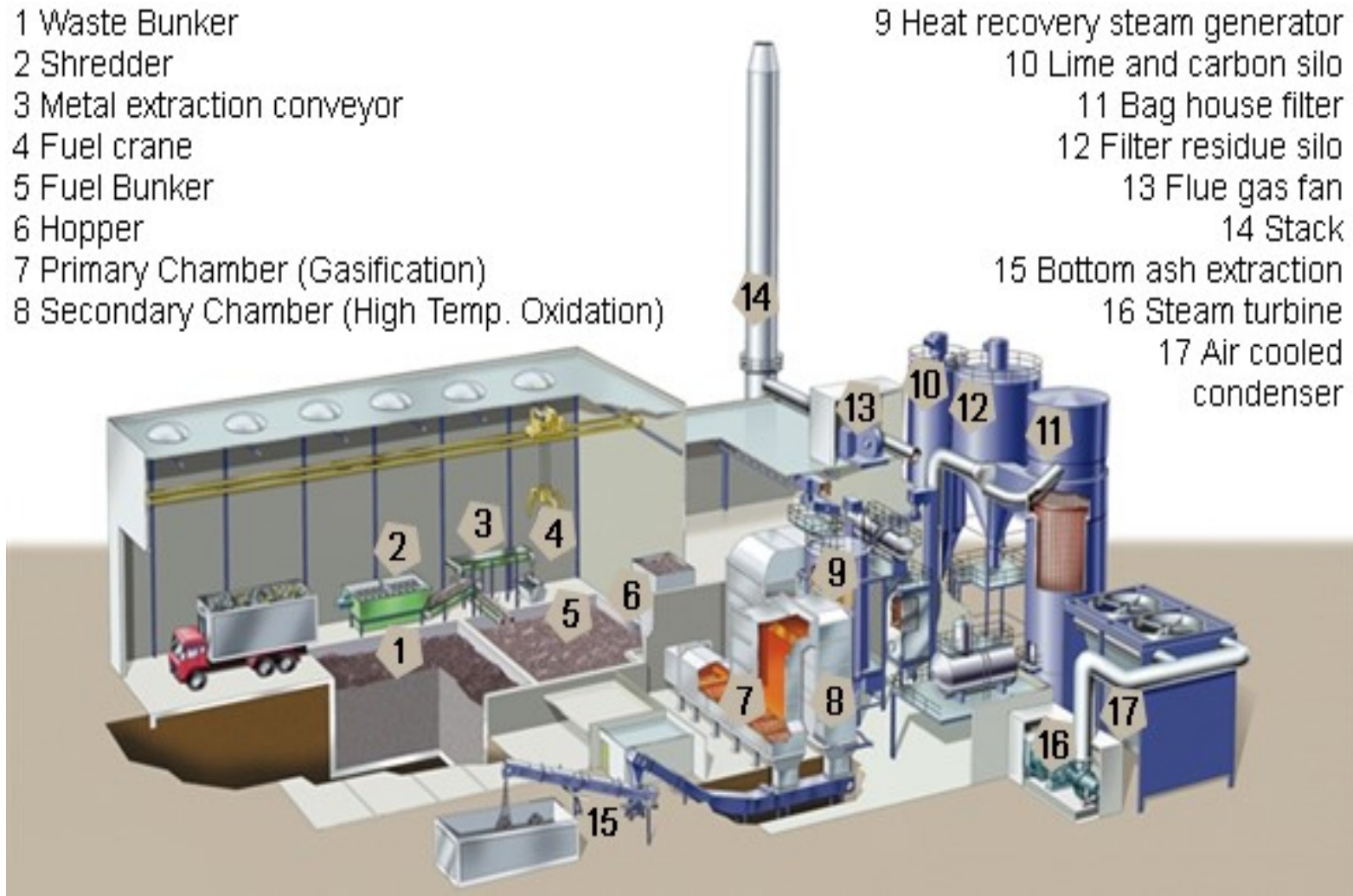


Figure 5: Existing Sanitary Landfill

