INTEGRATED SOLID WASTE MANAGEMENT PROJECT IN BALI, INDONESIA - UNFCCC CDM PROJECT 0938

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SUMMARY

A 20 year contract has been let on the Indonesian island of Bali to provide a novel yet soundly based waste disposal technology at the TPA Suwung landfill site which is situated near to Sanur beach, Denpasar. This paper addresses the opportunity afforded by the combined presence of landfilled, municipal solid waste (MSW) and new incoming, unsorted waste. Landfill sites produce landfill gas; unsorted municipal solid waste can be processed into a wet fraction, suitable for energy production through anaerobic digestion, and a dry fraction, suitable for energy production through thermal processes such as gasification. The combined use of GAsification, LandFill gas and Anaerobic Digestion is here referred to as GALFAD™. The paper provides a summary of the rational for the use of these particular technologies, explains the technology in outline detail and highlights issues related to its implementation. An analysis of GALFAD demonstrates that, where commercial issues relating to its application have been effectively addressed, it can be an attractive option for final waste disposal.

INTRODUCTION

The general viability of the TPA Suwung landfill site for renewable energy generation was first established during a site visit in the summer of 2003. Discussions were subsequently commenced with representatives from the various waste management authorities of Bali with a view to providing a turnkey system that would operate over the long-term and provide a commercially viable, sustainable and environmentally friendly solution to the problem of final disposal of MSW.

The project is now in the final process of project establishment. It is expected to be up and running and producing Carbon Emission Reduction credits (CERs) by December 2007 when a Kyoto protocol Conference of Parties is to be held on the island. The necessary discussions for the Site License Agreement, the Gas Agreement and the Power Purchase Agreement have been concluded. The issue of risk management has been paramount in establishing the project, some risks being less predictable than others.

THE ORIGINAL SITUATION

The TPA Suwung MSW dumping area is located on reclaimed tidal land on the north-eastern edge of Benoa Bay, close to Denpasar. The area of the site is twenty-four hectares. The site belongs to a protected forest area called “Tahura”. Ten hectares of this land has been assigned to the Governor of Bali from the Indonesian Ministry of Forestry to be used as the dump site which has been in operation for the last twenty years. Since 1984 the TPA Suwung site has received all of the MSW from the region of Denpasar and the southern region of Badung. In

2000 the northern region of Badung commenced dumping MSW at the site as well. According to the TPA Suwung site office, wastes are trucked in two hundred and fifty times per day from Denpasar and Badung, directly from hotels as well as from transfer stations located around the urban region. It is estimated that the site is taking approximately 800 tonnes per day, but accurate figures are hard to come by.

The dump site is not a sanitary landfill. There is no attempt to cover waste with soil. No attempt is currently made to control leachate, which runs more or less wherever gravity and rudimentary flow controls made from waste take it. The height of the piled waste is four to five metres and leachate is visible around all the blocks in the dumped area. There is also no visible attempt made to prevent dumped waste material escaping with tidal water.

Smoke and dust originally emanated from the site as well as, one might suspect, diseases, judging by the significant fly and mosquito population living in an ideal breeding environment. There is a permanent local population of human scavengers living and working on the site. To add to this unhappy picture, the site is also used as a dumping ground for raw, untreated sewage that is collected from septic tank systems throughout the urban area. Untreated sewage is emptied out of tanker trucks into neighbouring tidal creeks that flow amongst the waste piles.

In April 2004 a cooperation agreement was signed by the four regional waste management authorities, which handle all of the waste collection and disposal of Bali, and PT Navigat Organic Energy Indonesia, to implement waste management strategies for energy recovery for incoming waste and the conversion of landfill gas from existing waste into electricity. The project is designed to use revenues from electricity and carbon credits, to transform the site into a viable commercial source of income in an environmentally friendly and acceptable manner.

WASTE ANALYSIS IN BALI

One of the first issues to be addressed was that of establishing the waste stream composition. As a result of a lack of reporting and analysis, little data was available and that which there was appeared to be less than reliable. It was necessary, therefore, to make an assessment based upon other sources. From work in other regions of Indonesia it was established that the region of Surabaya, where a better quality of waste composition data is available, could serve as a basis for a waste composition in Bali. This was modified by assumptions made with regards to the impact of a significant element of hotel waste. It was, however, largely because of the uncertainty with regards to waste composition that the Phase One capacity was set at 500 tonnes per day. With an estimated capacity of 800 tonnes per day there will be adequate spare capacity to balance waste types to match the requirements of each energy production technology. This will give the project a firmer foundation for success and allow a detailed analysis of the waste arisings to be built up before Phase 2 is installed. Phase 2 will take the GALFAD concept to its maximum sustainable productive capacity.

Table 1 below presents the final working composition derived from available data.

WASTES COMPOSITION	MSW		C & I WASTES	
	Composition (%)	Quantity (ton/year)	Composition (%)	Quantity (ton/year)
PUTRESCIBLES	**59.1%**	**48,226**	**38.8%**	**30,420**
· food wastes	38.1%	31,090	23.3%	18,267
· green wastes	17.8%	14,525	12.6%	9,878
· other organics	3.2%	2,611	2.9%	2,275
PAPER	**9.9%**	**8,078**	**13.1%**	**10,270**
· packaging	0.5%	408	1.5%	1,176
· cardboard	1.5%	1,224	5.0%	3,920
· printed	2.0%	1,632	2.0%	1,568
· miscellaneous	5.9%	4,814	4.6%	3,606
PLASTICS	**7.3%**	**5,957**	**5.8%**	**4,547**
· PET	1.0%	816	0.0%	0
· PVC	1.0%	816	0.0%	0
· PE	0.4%	327	0.6%	470
· plastic film	0.5%	408	0.8%	627
· mixed & miscellaneous	4.4%	3,590	4.4%	3,450
METALS	**7.1%**	**5,794**	**7.7%**	**6,037**
· ferrous	4.6%	3,754	5.5%	4,312
· aluminum	2.5%	2,040	2.2%	1,725
GLASS	**6.8%**	**5,549**	**3.5%**	**2,744**
VARIOUS	**9.8%**	**7,996**	**31.1%**	**24,382**
· textile	0.0%	0	4.6%	3,606
· wood & timber	6.4%	5,222	10.3%	8,075
· excavated material	0.0%	0	3.5%	2,745
· concrete & bricks	0.0%	0	8.1%	6,350
· other	3.4%	2,774	4.6%	3,606
TOTAL	**100.0%**	**81,600**	**100.0%**	**78,400**

Table 1 : Waste composition assumed for Bali GALFAD

On the basis that wet organic waste passes to an anaerobic digestion process and dry organic waste passes to a gasification process, the maximum rate of thermal energy available per annum may be calculated, as shown in Table 2 below.

Table 3 indicates the energy available from the waste in terms of electrical energy production, assuming an internal spark ignition engine is used for biogas and a steam turbine for syngas. Whilst it may be possible to generate electricity by means of direct introduction of syngas into a spark ignition engine, this technology remains largely unproven over the long-term.

The total electrical energy available from incoming waste streams is, therefore, 9.1 MW. In practice, Phase 1 will be comprised of 5.6 MW of electrical production from gasification and 3 MW from anaerobic digestion. An additional 1 MW is anticipated to be available from existing landfilled waste, making the total Phase 1 capacity 9.6 MW.

SOLID WASTES CONTENT	Composition (%)	Quantity (ton/year)	Moisture (%)	Energy (kJ/Kg)	Efficiency (%)	Energy (MJ/year)
PUTRESCIBLES	**49.2%**	**78,645**				
· food wastes	30.8%	49,357	65.0%	4,180	70%	144,417,997
· green wastes	15.3%	24,403	65.0%	4,180	70%	71,403,763
· other organics	3.1%	4,885	65.0%	4,180	70%	14,292,925
PAPER	**11.5%**	**18,349**				
· packaging	1.0%	1,584	30.0%	15,815	75%	18,788,220
· cardboard	3.2%	5,144	30.0%	16,380	75%	63,194,040
· printed	2.0%	3,200	30.0%	18,550	75%	44,520,000
· miscellaneous	5.3%	8,421	30.0%	15,815	75%	99,881,214
PLASTICS	**6.5%**	**10,504**				
· PET	0.5%	816	5.0%	43,465	75%	26,600,580
· PVC	0.5%	816	5.0%	22,690	75%	13,886,280
· PE	0.5%	797	5.0%	43,465	75%	25,974,684
· plastic film	0.6%	1,035	5.0%	32,800	80%	27,163,648
· mixed & miscellaneous	4.4%	7,040	10.0%	32,800	75%	173,184,000
METALS	**7.4%**	**11,830**				
· ferrous	5.0%	8,065				
· aluminum	2.4%	3,765				
GLASS	**5.2%**	**8,293**				
VARIOUS	**20.3%**	**32,379**				
· textile	2.3%	3,606	25.0%	18,515	75%	50,079,372
· wood & timber	8.3%	13,298	20.0%	18,515	75%	184,653,798
· excavated material	1.7%	2,744				
· concrete & bricks	4.0%	6,350				
· other	4.0%	6,381	35.0%	8,534	75%	40,840,310
TOTAL	**100.0%**	**160,000**	**36.8%**	**8,440**		**998,880,831**

Table 2 : Mass balance and energy production

TOTAL ENERGY PRODUCED FROM BALI GALFAD PLANT	
Energy contained in MSW (MJ/year)	
Thermal energy in wet waste (MJ/year)	230,114,685
Thermal energy in dry waste (MJ/year)	768,766,146
Thermal capacity installed (MWth – 90% year)	**35.2**
Efficiency into electricity wet waste	38%
Efficiency into electricity dry waste	22%
Electrical energy potential wet waste (MWel)	**3.1**
Electrical energy potential dry waste (MWel)	**6.0**

Table 3 : Energy potential from accepted waste streams

THE PROPOSED SYSTEM

There are four key elements to the system that has been installed. These are as follows:

- Waste reception and separation into wet organics, dry organics and inerts/recyclables
- Gasification of the dry organics, converting these into a fuel-gas (syngas) for use in a boiler and steam turbine combination
- Landfill gas collection and use from deposited wastes. This will necessitate deposited waste reshaping and capping.
- Anaerobic digestion of the wet organics, converting these into biogas for use in internal combustion engines.

Waste from the system will include recyclable materials, such as metal and glass, as well as ash and compost, all of which may have a commercial value. Materials that do not have a commercial value will be deposited into the re-engineered landfill site.

The complete system, as shown in Figure 1, involves energy production from three separate sources, each derived from MSW. Landfill gas production would tend to decline with the passage of time but the internal combustion engines used for landfill gas may also be employed with biogas from anaerobic digestion.

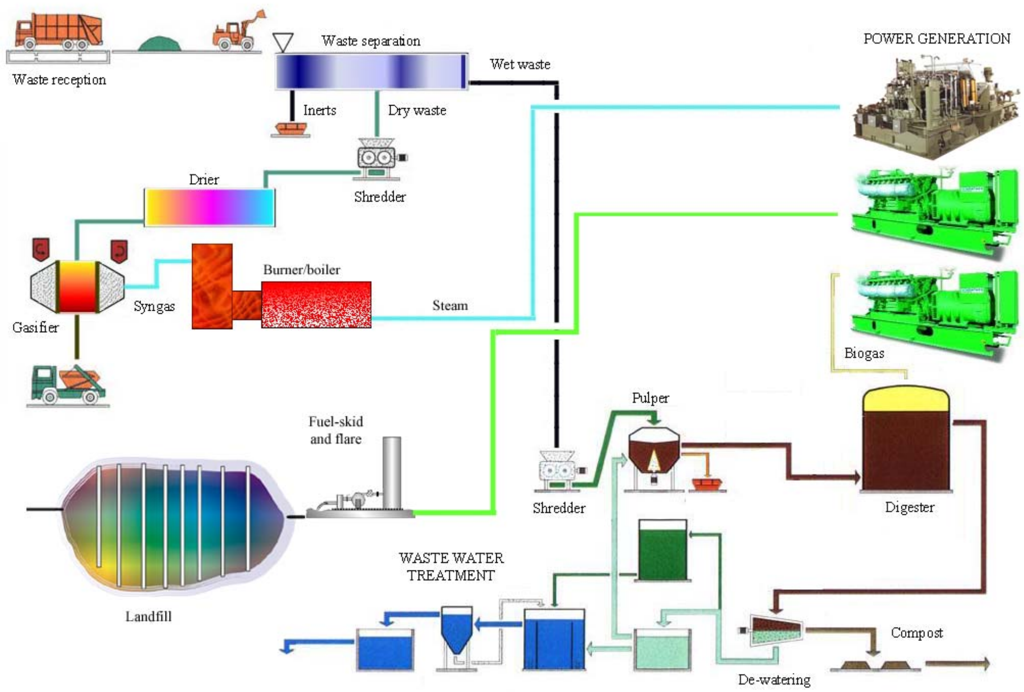

Figure 1 : The complete GALFAD system

Incoming waste is sorted into wet and dry components. In-organic components are also separated out at this point and recycled where possible, the simple criteria being one of economics. Wet waste passes to a pulper and into the anaerobic digestion process. Dry waste is passed to the gasification process. As conceived at present, syngas is not employed directly in internal combustion engines but is passed to a thermal oxidiser from which heat is used to raise steam. Whilst there is a loss in efficiency inherent in using this approach the technologies involved are well established and able to perform to the long-term requirement of reliable operation.

It is a fundamental principle of the technologies employed that they be proven and reliable.

DEVELOPMENT OF THE CURRENT WORKING SCENARIO

The project has metamorphosed over its period of implementation as a result of the unpredictable nature of business in Indonesia and the similarly unpredictable nature of the Clean Development Mechanism (CDM), by which carbon credits are generated.

It was originally thought that electricity revenue would be the backbone of the revenue streams. This proved to be difficult as negotiations with the electricity taker were less than encouraging. It was also believed that anaerobic digestion would play a major role in the production of energy from the waste. However, as a result of a ruling by the CDM Executive Board, anaerobic digestion was largely negated as a source of revenue from carbon credits. The ruling stated that the methane produced would need to be accounted for over a period of time, as if it had been in a landfill site.

The result of this latter development was that the anaerobic digestion element was re-thought and a greater emphasis was placed on landfill. Given the limited amount of land-space available for landfilling it was clear that the waste would need to be both deposited and removed once stabilised. This led to the development of the concept of the “structured landfill”, which is essentially a series of concrete chambers, each approximately 6,000 cubic metres in volume and open at one side and the top. Waste will be passed through a Materials Recycling Facility (MRF) upon receipt on site. The cleaned, biodegradable organics will be landfilled in the structured landfill. Leachate will be recirculated through the deposited waste to reduce the need for leachate treatment. This will also have the effect of encouraging methane production, as happens in many existing landfills around the world. After a period of time the waste will be stabilised and removed from the structured landfill cell in which it resides for curing and use as a compost. The cell in question may then be re-loaded with waste.

Phase 1 of the project now consists of landfill in a temporary landfill, where waste is currently being deposited, landfill in the structured landfill, compost production and a small element of recyclables collection. In actual fact, most of the high-value recyclables are removed by entrepreneurs before the waste reaches the landfill site. Phase 2 remains the use of anaerobic digestion and gasification. It is possible that as the CDM framework develops it will be possible to use full anaerobic digestion.

FINANCIAL CONSIDERATIONS

The project produces the following revenue stream:

1. Carbon credits
2. Electricity sales revenue
3. Compost sales revenue
4. Recyclables sales revenue

The main revenue stream is that of carbon credits. Without this source of income the project would not be feasible. The electricity price is quite low. There is talk of increasing the rate paid for renewable energy in Indonesia but this is still not settled. A big issue with electricity is that the national electricity supplier, which would be the customer for electricity sales, is itself in financial difficulties originating from the financial crisis of 1997. A power purchase agreement with this entity is still difficult to treat as bankable.

Compost is considered to be a windfall revenue element as it is largely driven by market forces which are difficult to quantify or predict. There is a demand for compost and the market may be significant at times but it would not be possible to include this revenue stream in a serious assessment of revenue potential.

The current cost of Phase 1 is estimated at approximately nine million US dollars. Phase 2 is still subject to some uncertainty but the budget is approximately ten million dollars.

RISK

The issue of risk analysis and management is paramount in the establishment of a project such as that under development in Bali. For finance to be available all visible risk should be mitigated to a point where the project may be considered “bankable” or fundamentally commercially viable and risk free.

The key risks are stated in Table 4, together with a brief description of mitigation measures. It is in this area that the bulk of project development activities lie, once financial viability has been demonstrated. In practice a project such as the Bali waste management facility is relatively small and sovereign guarantees are difficult to obtain. The issue of size is one which also affects decisions for involvement by World Bank bodies.

Risk Title	Description	Mitigation measures
Fuel-supply	The project must be certain of receiving unsorted MSW for the next 20 years	Enforceable guarantee required from local government
Energy sales	All energy produced must be sold to an end user who will pay a guaranteed price	An acceptable Power Purchase Agreement must be in place with the local electricity company
Contracts	Contracts between the various parties must be correctly structured and enforceable	Contracts must be carefully scrutinised by bankers’ legal representatives
Political	Politics must not be allowed to interfere with project implementation and operation	Sovereign guarantees, protection under the World Bank umbrella or insurance cover
Country	This is a factor related to social stability	Sovereign guarantees, protection under the World Bank umbrella or insurance cover
Technology	The technology should be such that it can be certain it will generate the cash flow required	Technology verification
Project sponsors	The project sponsors should be of credible financial standing	Revue of balance sheets and assets
Guarantees	Guarantees are required from various parties covering a number of issues, such as Technical Completion and Financial Completion	Guarantees must be seen to be of substance

Table 4 Risk management requirements

A good many of the above risks can be covered by insurance companies, but at a significant cost. It would be normal for the UK Export Credit Guarantees Department (ECGD) or Hermes, its German equivalent, to require up to 10% of the project value for such a facility.

SUMMARY

The Bali GALFAD project is viable with the technology to be employed as a result of the significant capital cost savings available in Indonesia. Manufacturing costs can be as little as one fifth of equivalent European costs. A considerable amount of engineering production from the region is delivered to Japanese companies, resulting in manufacturing quality being high.

With the recent adoption of the Kyoto Protocol by Indonesia, carbon credits may be obtained and sold under the provisions of the Clean Development Mechanism (CDM). This additional facility adds to the attractiveness of an overall final disposal option for MSW in South East Asia, where the waste stream can be converted from a major environmental liability into a viable social asset.

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UNFCCC CDM Project 0938 – Integrated Solid Waste Management Project in Bali, Indonesia

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