Assessing the Feasibility of Waste to Energy Technologies in Malta

Waste to Energy Working Group

Ministry for Rural Affairs and the Environment

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Executive Summary

This report is aimed to assess the feasibility of introducing waste to energy technologies in the Maltese Islands as a means of treatment for solid waste as well as to recover energy from the waste generated. Moreover the report is also aimed at assessing the applicability of certain technologies to existing waste streams currently being generated. This report has been prepared by the Working Group on Waste to Energy (hereinafter referred to as the Working Group) that was appointed by the Minister for Rural Affairs and the Environment on the 7th January 2005.

The report is structured as follows:

Current State of Play - provides an overview of the presentations given to the Working Group by Government's leading regulator, operators and waste producers.

Legal Backdrop - aims to list the laws and regulations that were taken into account in the preparation of this document.

Wastes Available for Conversion to Energy - identifies which wastes are suitable for energy recovery. It will state which of the various waste streams should be excluded or treated separately from the main stream.

Overview of Waste to Energy Processes - examines the different processes for waste treatment with estimates of energy derived and volume reduction. Moreover waste and energy calculations together with the assumptions made for such derivations are also included.

Available options - considers potential technologies outlining any issues and putting forward recommendations thereto.

The Environmental Aspect - describes the environmental measures and impacts applicable for each process such as environmental standards, regulatory issues, permitting, etc.

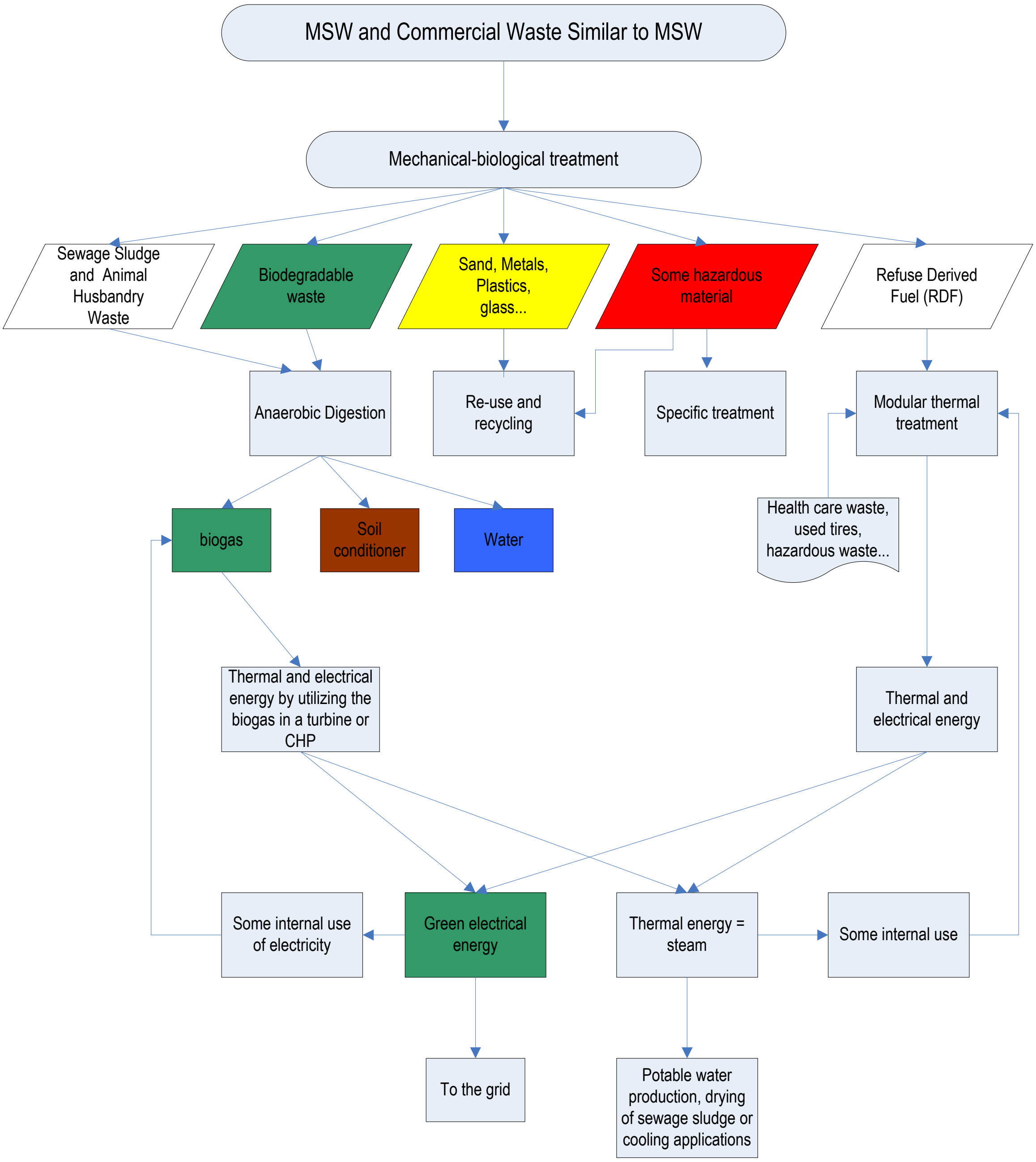
Financing Mechanisms - outlines the financing mechanisms that are available for the financing of the said plants and will put forward methodologies that could be adopted in this respect.

Siting Considerations - puts forward considerations regarding the siting of such plants. These recommendations are indicative and serve only as a means to ensure that whoever takes on any of these recommendations will have been directed appropriately towards the ultimate siting.

The salient recommendations put forward in this report are of a financial, technological and siting nature and include:

- That Government farms out the development of these facilities to the private sector in consonance with the *raison d'etre* with which WasteServ Malta Limited was set up. It is in this context that the model combining Design-Build-Operate-Finance and Concession is the most favoured and is being recommended to Government for consideration.
- That the integrated model for waste management be operated as outlined in the schematic overleaf.

Scenario 4: The integrated waste management and treatment approach for Malta



- o That, without prejudice to any planning and environmental procedures and to any further investigations that might be considered appropriate, Government is advised to consider the following technologies for the proposed facilities located at the sites suggested hereunder:

  - A Mechanical-biological treatment plant (includes the mechanical treatment plant and digester) that we recommend should stay at Maghtab due to traffic movements, land availability, waste management permits, etc;

  - For the RDF, the following options are available:

    - o Option 1: thermal treatment plant (incineration/gasification) for the production of electricity as a stand alone facility. This stand-alone facility may be located at an already committed site. This is the least preferred option;

    - o Option 2: thermal treatment plant (incineration/gasification) for the production of steam or electricity to maximize on synergies with existing or proposed power generation plants;

    - o Option 3: thermal treatment plant (incineration/gasification) for the production of steam for the desalination of water. Potential sites include existing RO sites,. WSC need to upgrade their present capacity to improve their water quality and some synergy exists.

  - Cognizance needs to be given to the fact that the digestor for the sewage sludge is being proposed to be located adjacent to the proposed largest sewage treatment plant to be constructed at Malta South. This gives the opportunity for additional synergies to be developed by utilising the plant to also accept animal husbandry waste from the southern area of the Maltese Islands for treatment.

  - Currently, all solid waste, excluding C&D waste, generated from Gozo is transported for treatment to Malta. It must be noted that the organic fraction of such waste comprises of around 50% by weight in water which makes it uneconomical to transport. Consequently, it is being proposed to develop a digestor / gasifier for the treatment of all waste in Gozo in line with the proximity principle. Additional efforts need to be undertaken in order to ensure that separation at source is reinforced in order to deliver as clean a waste as possible to the facility. Moreover, this facility could also treat other waste such as animal husbandry waste as well as sewage sludge from the Gozo wastewater treatment plant. In respect of siting, the Committee advises Government to conduct a site selection exercise in the proximity of the site that is currently earmarked for the development of a transfer station, which development is still being considered by MEPA.

  - Animal manure is to be treated in principle as recommended by the Draft Agricultural Waste Management Plan for the Maltese Islands. However Government should steer away from replicating facilities at different sites. On the contrary consolidation of the waste to be treated at ‘consolidated’ sites in the areas mentioned is the recommended way forward.

01. Purpose

The purpose of this report is to assess the feasibility of introducing waste to energy technologies[1] in the Maltese Islands as a means of treatment for solid waste as well as to recover energy from the waste generated. Moreover the report is also aimed at assessing the applicability of certain technologies to existing waste streams currently being generated.

This report has been prepared by the Working Group on Waste to Energy (hereinafter referred to as the Working Group) that was appointed by the Minister for Rural Affairs and the Environment on the 8th January 2005.

01.1 Terms of Reference

The Terms of Reference assigned to the Working Group on Waste-to-Energy were the following:

- assess the potential of energy from the waste fractions generated in the Maltese Islands that will not be treated at the upgraded St Antnin Plant as well as other waste fractions with a significant calorific value resulting from this or other treatment processes;

- obtain information and evaluate technologies suitable for minimising the amount of waste going to landfill. Technologies must be proven and readily available to treat solid waste to help meet the relevant environmental and other waste management obligations. Key considerations upon which such an assessment will be made include, but are not limited to capital/recurrent cost per tonne, track record, quality and quantity of residue/emission, throughput, size of facility (including floor space) as well as energy recovery content per tonne of waste treated. The obligation specified in the Strategy to develop a special waste incinerator is to be considered in this evaluation;

- recommend a number of preferred technologies and a number of potential sites where such a facility may be developed. Propose a project timeframe to the Strategy Team[2] for the development of this facility;

- identify the most advantageous financing mechanism and the most efficient procurement process to help finalise the timeframe mentioned above; and

- to liaise with representatives of foreign public authorities for the sharing of experience and the resulting technical guidance.

01.2 Methodology

The methodology that was adopted by the Working Group consisted of the following:

- the Working Group met regularly for a number of times in order to discuss the approach towards the project, to evaluate the feedback obtained from presentations from third parties as well as to discuss various technical issues related to the subject;

- all major stakeholder entities who contribute a significant amount of waste (Water Services Corporation, Malta Environment and Planning Authority, WasteServ Malta Limited, Animal Husbandry Division, Food and Veterinary Services Division, and the Health Division) were invited and conducted a presentation to the Working Group outlining the quantity and quality of

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[1] Waste to energy technologies are defined in this report as being those technologies that through the treatment they provide can produce some form of energy recovery. Thus, for the purpose of this report for example, anaerobic digestion is a technology that is considered to form part of those technologies from which energy can be recovered.

[2] A Strategy Team was appointed concurrently with the Working Group on Waste-to-Energy in order to revise the Solid Waste Management Strategy for the Maltese Islands.

waste generated and/or handled by these entities as well as to communicate any plans for the management of such waste;

- a Request for Information was also issued to all those individuals/companies who wished to contribute towards providing the Working Group with information on tried and tested technologies which information was in line with the demands placed upon the Working Group by its Terms of Reference; and

- consultations were held with foreign public sector experts for the sharing of experience as well as for technical guidance.

01.3 Acknowledgements

The Working Group wishes to acknowledge all those individuals and entities who in any way contributed to the workings of the Working Group on this project. Their invaluable help has been very much appreciated.

02. Background

The Solid Waste Management Strategy that was published in October 2001 contemplated the possible introduction of waste to energy treatment technologies for around the year 2013. This meant that up till such time a heavy dependancy would exist on landfilling and composting facilities.

On the 7th January 2005, following Cabinet approval, the Minister for Rural Affairs and the Environment appointed a Strategy Team to update the Solid Waste Management Strategy for the Maltese Islands (2001) as well as a Working Group on Waste to Energy in order to evaluate the feasibility of proven technologies and to put forward recommendations to Government on the ideal technology or technologies to be adopted. It is important to realise that the workings of the Waste to Energy working group are directly linked to those of the Strategy Team and the findings and recommendations of the former are expected to be reflected in the updated Strategy document.

Apart from the regular discussions held by the Working Group, two immediate tasks were taken in hand namely – the issuing of a Request for Information for those persons or entities who wished to contribute to the knowledge base within the Working Group as well as the identification of major Government waste producers, operators and regulators who were invited to present their waste generating activities, the quantification of the waste expected to be generated from such activities and any plans for the management of such waste.

The report is being structured as follows:

Section 3 — **Current State of Play**

This section aims to provide an overview of the presentations given to the Working Group by Government's leading regulator, operators and waste producers.

Section 4 — **Legal Backdrop**

This section aims to list the laws and regulations that were taken into account in the preparation of this document.

Section 5 — **Wastes Available for Conversion to Energy**

The report will state which wastes are suitable for energy recovery. It will state which of the various waste streams should be excluded or treated separately form the main stream.

Section 6 — **Overview of Waste to Energy Processes**

Overview of different processes with estimates of energy derived and volume reduction. Moreover this section provides the waste and energy calculations together with the assumptions made for such derivations.

Section 7 — **Available options**

The technologies that are to be put forward are considered outlining any issues and putting forward recommendations thereto.

Section 8 **The Environmental Aspect**

The description of the various processes will include the environmental measures in each process. This section will deal specifically with environmental standards, regulatory issues, permitting, etc.

Section 9 **Financing Mechanisms**

This section will outline the financing mechanisms that are available for the financing of the said plants and will put forward methodologies that could be adopted in this respect.

Section 10 **Siting Considerations**

This section aims at putting forward considerations regarding the siting of such plants. These recommendations are indicative and serve only as a means to ensure that whoever takes on any of these recommendations will have been directed appropriately towards the ultimate siting.

03. Current State of Play

In order to ensure that an appropriate stocktake of all the waste that could potentially serve to recover energy therefrom, the Waste-to-Energy Committee invited the principal stakeholders to deliver a presentation outlining the volumes and types of waste generated by their entity and any places in hand for the treatment of such waste.

This Section provides an overview of the details given during the respective presentations and captures other information gathered during follow up meetings. It portrays the views and intentions of Government entities in relation to waste management and its treatment and identifies:

- the amount of waste being generated;
- any treatment being applied to such waste; and
- plans and proposals for new treatment processes and their status.

The information provided in this Section summarises the key points highlighted by the following Government entities in their presentations to the Waste-to-Energy Committee:

- MEPA;
- WasteServ Malta Limited;
- Water Services Corporation;
- Animal Husbandry Division;
- Food and Veterinary Services Division; and
- Health Division.

03.1 Malta Environment and Planning Authority

In October 2001, MEPA finalised the Waste Management Subject Plan[3]. The purpose of this report is to provide strategic guidance on how to deal with waste in a sustainable manner. The strategic policy direction presented in the report is based on national and EU legislation and builds upon the following key principles:

- waste hierarchy;
- self sufficiency;
- environmental protection; and
- producer responsibility (PPP).

The Waste Management Subject Plan reviews the state of existing waste management facilities and identifies constraints for the development of future waste management facilities. It also proposes the types of waste management facilities required based on projected waste flows, namely:

- bring system outlets;

[3] Malta Environment and Planning Authority "Space for Waste: Waste Management Subject Plan" October 2001.

- incinerators;
- microwave technology;
- composting capacity;
- Municipal Solid Waste (MSW) pre-treatment;
- inert waste landfills;
- engineered landfills (Malta); and
- engineered landfill or transfer station (Gozo).

The report gives a list of criteria that can be used to assess the suitability of individual sites and to select the most appropriate sites for waste management facilities. The Subject Plan also outlines strategic policies and guidance specific to the waste management option selected including guidance on the submissions of waste-related planning applications.

In its report, MEPA also put forward policies to ensure that the environment is protected and that waste management facilities that are set up do not undermine the environment for future generations.

03.2 WasteServ Malta Limited

Being the manager and operator of public waste management facilities, WasteServ collects data about the waste disposed at these public facilities. Waste is grouped into three categories, namely inert, hazardous and non-hazardous. **Table 1** gives the amount of waste generated in the year 2004 categorised by type of waste as reported by WasteServ.

Table 1: Waste generated in 2004

Type of waste	Amount in tonnes	
Inert		**2,200,000**
Non-hazardous		
Maghtab/Ta' Zwejra	253,050	
Sant Antnin	34,052	
Qortin	17,183	
		304,285
Hazardous		
Solids	5,386	
Liquids	4,297	
Sludges	3,679	
		13,362
Total	**2,517,647**	

Source: WasteServ Malta Limited

Inert waste is currently being deposited in privately owned, disused quarries. As from January 2005, the subsidy by Government on the deposit of Construction and Demolition waste was removed. Consequently, the cost of disposal is now entirely being borne by the generators of such waste. Non-hazardous waste is being disposed of at Sant Antnin plant, Ta' Zwejra, Qortin (for transfer to Malta) and other private facilities that recover paper, plastic, metals and other material such as PaperMalta, C&V Polymers, Greenskips, Edible Oil Refinery Company Limited and metal scrap dealers. Hazardous waste is being disposed in private facilities; for example, some waste lubricating oils, are being collected by Waste Oils Company Limited. Other fractions are either stored and/or exported for treatment abroad.

Non-hazardous waste deposited at Maghtab and Ta' Zwejra in 2004 consisted of:

- o mixed Municipal Solid Waste;
- o commercial/industrial waste – which is partly recovered for recycling;
- o Category 3 animal waste;
- o agricultural waste; and
- o seaweed.

The non-hazardous waste deposited at the Sant Antnin plant is either recycled to produce compost or stored for eventual treatment. Non-hazardous mixed MSW generated in Gozo is being transported to Malta and is then either landfilled or composted while the recyclable material from commercial/industrial waste is recovered. **Table 2** provides a more detailed breakdown of waste being disposed in public facilities for the period 2001–2004 for Malta and Gozo. The amount of waste generated by the individual Government entities under review will be given in the subsequent sections.

Table 2: Waste handled at public facilities in Malta and Gozo

	Malta (tonnes)				Gozo (tonnes)		
Waste Stream	**2001**	**2002**	**2003**	**2004**	**2001**	**2002**	**2003**
Municipal Solid Waste							
Domestic	105,621.42	125,772.52	125,057.32	124,723.62	7,548.54	9,071.1	8,749.94
Hotels/Restaurants	19,100.96	18,193.18	16,597.80	15,186.42	2,342.59	2,451.21	1,711.06
Hospital Kitchen Waste	1,441	1,772.38	1,856.62	3,270.06	0.00	0.00	0.00
Sant Antnin	32,103.38	15,553.22	24,434.33	35,138.49	NA	NA	NA
Debris Material							
Cons/Demolition/Excav.	150,527.24	206,083.34	154,297.71	26,774.22	49,824.23	53,291.92	17,515.26
Roads/street debris	7,814.38	4,593.12	14,312.78	6,196.12	327.85	286.54	-
Commercial/Industrial							
Commercial	290.24	235.44	252.56	199.62	2.1	15.92	38.36
Industries	21,360.58	20,507.46	23,034.16	21,006.08	864.82	460.32	22.86
Paper/Cardboard/Wood	1,941.9	2,532.52	2,955.82	2,659.62	123.44	115.97	100.87
Rotten Foodstuffs	181.55	95.18	1,058.58	56.26	19.08	0.00	0.00
Plastics/Rubber	877.94	1,293.1	879.94	320.26	12.66	3.66	18.10
Metal Products	80.08	31.2	59.28	40.32	49.26	306.14	95.37
Mixed Trade/Municipal							
Bulky Refuse	32,395.18	30,563.92	42,899.24	45,148.44	9,433.2	7,829.99	6,482.70
Agriculture	3,653.68	3,153.76	3,531.04	2,159.66	709.6	350.16	579.51
Beaches/Seaweed	1,705.08	1,593.86	2,736.74	2,438.40	413.54	502.80	361.65
Mixed							
Sludge	1,530.42	1,459.86	1,419.12	881.86	0.14	3.24	0.00
Slurry	12,318.6	7,826.92	6,384.84	2,702.58	0.00	0.00	0.00
Tarmac Fine Dust	2,768	3,126.58	1,883.04	155.70	0.00	0.00	0.00
Abattoir/Carcasses	2,849.76	3,008.48	3,424.80	5,450.20	448.58	544.15	644.03
Special Waste	-	-	757.36	76.74	1.86	4.62	-
Total	**398,561.39**	**447,396.04**	**427,833.08**	**294,584.67**	**72,121.49**	**75,237.74**	**36,319.71**

Source: Ministry of Rural Affairs and the Environment

WasteServ carried out an exercise to assess which types of waste have the potential to generate energy and identified the following categories of waste:

- non-hazardous waste:
  - mixed Municipal Solid Waste;
  - commercial/industrial waste;
  - agricultural wastes;
  - seaweed; and
  - sewage sludge.
- hazardous waste:
  - other solids such as oiled rags and oil filters;
  - solvents;
  - other liquids such as waste inks and waste chemicals; and
  - sludges.

The generation of energy from waste depends upon future waste generation trends and the efficiency of the plant and the technology selected.

03.3 Water Services Corporation

The waste generated by the Water Services Corporation (WSC) consists mainly of sludge from the existing and future wastewater treatment plants. **Table 3** shows the estimated sewage sludge production (dry content only) for the period 2005 to 2010. The total sludge load (including the liquid fraction) is estimated to amount to 8,800 tonnes in 2005 and 46,650 tonnes in 2010.

Table 3: Annual estimated sewage sludge production (Dry solid content)

Year	Wied Ghammieq STP (tonnes)	Ic-Cuminja STP (tonnes)	Sant Antnin STP (tonnes)	Gozo STP (tonnes)	Total (tonnes)
2005	-	-	1,760	-	1,760
2006	-	700	1,760	660	3,120
2007	-	760	1,760	660	3,180
2008	6,150	760	1,760	660	9,330
2009	6,150	760	1,760	660	9,330
2010	6,150	760	1,760	660	9,330

Source: Water Services Corporation

The Corporation also generates other wastes, namely:

- scrap metal – this is currently being sold for reuse;
- spent vehicle engine oil – this is being carried away for processing; and
- industrial solid waste – this is being separated, with inert waste being disposed in disused quarries and the remainder being landfilled.

The responsibility for the collection and treatment of wastewater was assigned to the WSC in October 2004. The Corporation is responsible for the management of the Sant Antnin Sewage Treatment Plant (SASTP). The SASTP has the capacity of 17,000 m^3 per day. According to the 'Maltese Code of Good Agricultural Practice', the development of three additional sewage treatment plants is estimated to increase the supply of treated sewage effluent by a total of 26.7 million m^3 per year. A report by the Malta Resources Authority (2004)[4] states that the wastewater of the Maltese Catchment

[4] Malta Resources Authority *Economic Characterisation of the Maltese Water Catchment District – Draft* November 2004

District is mainly disposed of in the sea from the Gozo, Cumnija and Wied Ghammieq outlflows. According to this same report, the majority of households and commercial enterprises are connected to the main sewer and the only villages that are not connected are Gharb, Bidnija and Bahrija since WSC considers the infrastructural expenditure required to connect these villages to be prohibitive due to their location.

The Water Services Corporation has formulated proposals for the treatment of the wastewater it generates. In line with these proposals it has set the following objectives for 2005:

- conduct an assessment and analysis of the environmental issues of the activities of the Corporation; and
- formulate a corporate Waste Management Strategy.

The WSC is proposing three sewage treatment plants, one in Gozo and two in Malta, namely the:

- Gozo plant;
- Malta North plant; and
- Malta South plant.

The Corporation is recommending that all sewage sludge generated in the Gozo and Malta North plants be transferred to the Malta South plant which would be the only plant capable to recover energy from sewage sludge. The WSC believes that it would not be feasible to have all three plants generating energy.

The WSC envisages that future waste management plans and processes at the Corporation would be based on:

- energy conservation;
- energy generation; and
- the use of alternative water sources.

In respect of sewage sludge, it is being proposed that, in order to achieve economies of scale, all sludge generated from the sewage treatment plants will be directed towards the Malta South plant where it will be treated to recover energy. The treatment method has not yet been decided although one possible option could be digestion.

03.4 Animal Husbandry Waste

The generation of animal waste arising from livestock farming has important environmental implications due to the potential contamination of soil, water supplies and air if such waste is not disposed of properly. Livestock breeding affects the environment through the generation of manure. Estimates of manure production, provided by Jackson[5] indicate that 2.45million kg of nitrates are produced annually. To this end, Government has initiated a process to assess possible treatment and disposal processes for the proper disposal of animal waste and the potential use of such waste. The Animal Husbandry Division in conjunction with an appointed consultancy firm, have completed the Agricultural Waste Management Plan. Actual measurement and analysis of animal waste was carried out in order to verify the figures presented in the Jackson report (2001).

The study carried out by Jackson (2001) estimated that the quantity of farmyard waste (animal manure) generated in Malta and Gozo amounts to approximately 450,000 tonnes per year. The same report estimated the dry matter content of this waste to amount to 101,000 tonnes per year.

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[5] Peter Jackson (2001) *Animal Waste in the Maltese Agriculture*

Table 4 provides data on the volume of manure, which is a by-product of breeding animals, and its nutrient content generated annually. The values in the Table are based on book values from USA and UK sources since no actual figures for Malta are available to date. As shown in the Table, annual nitrates production amounts to 2.45 million kg.

Table 4: Estimated annual production of manure and nutrients

Animal Type	Total Fresh Manure (000s kg)	Total Dry Manure (000s kg)	Nitrogen (000s kg)
Cows	72808	31437	385 – 428
Beef and Heifers	46000	18350	225 – 250
Pig Units	210517	12631	255
Broilers	10000	8000	126 – 510
Layers	17500-22000	6387-8000	255 – 560
Sheep	5250	700	60
Goats	2650	260	35
Rabbits	23115	5199	265 – 330
Horses	5077	760	31
Total	**454,718**	**101,448**	**1637-2409**

Source: Jackson (2001) Animal Waste in the Maltese Agriculture

Preliminary tests carried out by the consultants suggest that the actual figure for the generation of manure/slurry could be as high as 600,000 tonnes. However, other tests by the same firm indicate that manure might actually be more dilute than it was believed to be in 2001. This results in the overall dry matter to be actually less than was predicted by Jackson (2001). Should animal manure be extremely high in water content, the most feasible process for generating electricity and heat energy from this waste would be through wet anaerobic digestion. Through this process, the nutrients would be retained and re-distributed to farmers to use as fertilisers. This treatment process would also provide enough energy required to run the treatment plant and might potentially produce a surplus for export to the grid.

The consultants submitted their proposals and recommendations in May 2005 and recommend a plan and treatment process for the treatment of animal waste. This should be in compliance with EU regulations and Directives and should entail the least capital and operational costs. It is worth noting that this report is currently being reviewed by Government and any proposed version will be subject to a public consultation exercise prior to being finalised.

03.5 Food and Veterinary Services Division

Waste generated by this sector comprises the waste generated by the abattoir and that arising from veterinary services. The waste arising from the abattoir used to be dumped at the Maghtab landfill prior to April 2004 and consisted of:

- dead animals (excluding animals with prion diseases(i.e. with transmissible spongiform encephalopathies, TSE));
- slaughterhouse by-products; and
- food waste.

Abattoir waste is currently being incinerated using the mobile incineration facility at the Malta Abattoir. This incinerator does not have sufficient capacity to burn all the waste generated. Thus, the remaining Category 3 waste is collected and disposed of by WasteServ. The new ‘fixed’ incinerator will have the potential to treat all waste arising from this sector.

Following the adoption of Directive 90/667/EEC and Regulation 1774/2002, waste generated by the abattoir is being classified differently. Animal waste is classified as either high risk or low risk material and animal by-products are classified:

Category 1 animal by-products presenting TSE risk or an unknown risk;

Category 2 animal by-products presenting risk related to animal diseases and/or residues of veterinary drugs; and

Category 3 animal by-products derived from healthy animals.

Table 5 gives projections of waste generation by the Malta Abattoir. The Table provides the amount of waste generated classified per category of waste and by type of waste.

Table 5: Projections of waste flows by the Malta Abattoir

Type of waste	Amount of waste (tonnes)		
	Category 1	Category 2	Category 3
Pork			2000
Beef	300		40
Poultry			5800
Airport waste	100		
Hatchery waste	100		
Hospital waste (kitchen)			1100
Fallen stock		250	
Fish waste			400
Blood	1400		
Gozo Abattoir	100		
Catering waste			8000
Total			**19,590**

Source: Food and Veterinary Services Division

The volume of waste generated by the Gozo Abattoir is significantly lower than that generated by the facility in Malta. Estimates for the period 1st May 2004 to date show that the volume of waste generated amounts to 335,245 kg. The waste consists mainly of:

- fallen animals;
- condemned meat;
- poultry offal; and
- waste from butchers.

The Gozo Abattoir is equipped with an incinerator which has been upgraded in 2004. It is envisaged that in the future, the Gozo Abattoir will continue to make use of the current incinerator.

The Food and Veterinary Services Division is recommending the setting up of a number of plants, apart from an incinerator, to provide for the treatment of the three categories of waste. Category 1 waste can be disposed of either through an incineration or co-incineration process. Similarly, for Category 2 and Category 3 waste, an incinerator will also be needed to dispose of part of the waste arising under these two Categories. A proportion of the waste generated by the processing of the three categories of waste will have to be landfilled. The Working Group notes that all three Categories of waste can be incinerated using the same plant subject to adherence to EU Directive 1774/2002. The Directive requires that Category 1 be incinerated. Category 2 waste can either be incinerated or co-incinerated. This category of waste can, if treated, also yield compost, oleo (chemical), fish ensilage and fertiliser. The Composting Plant at Marsascala does not satisfy the Directive's requirements, particularly the sterilisation process prior to composting. Moreover such a treatment process would have a negative environmental impact. The possibility of producing fish ensilage is also not being considered since this would require chemical treatment and disposal facilities. Therefore, it is envisaged that Category 2 waste will be incinerated. The manure component of this waste category is to be collected prior to processing of such waste and can be used as fertiliser.

The following plants may be considered as potential options in the case of treatment and disposal of Category 3 waste:

- o incinerator;
- o technical plant producing pharmaceuticals, blood products, hides and skins, wool, processed manure, gelatine, glue, game trophies and other products; and
- o pet food plant producing pet food from waste.

03.6 Health Division

The Health Division has formulated a Clinical Waste Management Plan for hospitals and healthcare facilities of the Division. The total amount of clinical waste generated is estimated to be 3.35 kg of waste is generated per hospital bed per day. The number of hospital beds in Malta and Gozo amounts to 1963 beds[6]. This figure includes hospital beds in the following facilities:

- o Public Hospitals:
  - – St. Lukes Hospital;
  - – Sir Paul Boffa Hospital;
  - – Gozo General Hospital;
  - – Mount Carmel Hospital; and
  - – Zammit Clapp Hospital.
- o Private Hospitals:
  - – St. Philip's Hospital;
  - – Capua Palace Hospital;
  - – St. James Hospital; and
  - – St. Mark's Clinic.

The total amount of clinical waste generated by hospitals in Malta is estimated to amount to 6,576 kg per day or 2.4 million kg per year. Table 6 provides the amount of clinical and domestic waste generated in St. Luke's Hospital in a given year and the estimated clinical and domestic waste to be generated in the New Hospital Project in a year.

Table 6: Waste generated in St. Luke's Hospital and in the New Hospital Project

Category of Waste	St. Luke's Hospital (tonnes/year)	New Hospital Project (tonnes/year)
Clinical/healthcare risk waste		
Clinical waste incl. Sharps	130	260
Clinical waste delivered from other healthcare centres (total approx. 3500 beds) to the New Hospital Project for decontamination	-	(300)
Pharmaceutical products, cytotoxic and hazardous chemical waste	15	15
Radioactive waste	0.5	0.5
Conventional Domestic waste		
Domestic waste (non organic and organic domestic waste)	1315	1315
Paper/cardboard for recycling	125	125

[6] Ministry of Health Publications *The Health Care System in Malta* www.health.gov.mt viewed 24/03/05, page last updated 02/02/05.

Plastic for recycling	45	45
Category of Waste	**St. Luke's Hospital (tonnes/year)**	**New Hospital Project (tonnes/year)**
Glass for recycling	15	15
Metal for recycling	40	40
Special domestic waste (scrap metal, condemned items such as furniture, equipment, non-reusable electronic items, reconstruction waste, etc)	85	85
Total	**1,770**	**1,900**

Source: 'Construction Hospital Waste Management Plan Report' Skanska October 2001

Table 6 shows that the total waste generated in one year in the New Hospital Project will amount to 1,900 tonnes. This corresponds to a daily rate of 6.1 kg per bed calculated on the 850 beds (Skanska report 2001).

Hospital waste is grouped under two main categories: clinical waste and domestic/conventional waste. Clinical waste is categorised as follows:

- Group A – human tissues, surgical dressings and waste materials;
- Group B – discarded, used syringe needles and similar contaminated items;
- Group C – microbiological cultures and waste from pathology departments;
- Group D – expired or unutilised pharmaceuticals and all cytotoxic wastes; and
- Group E – items used to dispose of urine, faeces and other bodily secretions and excretions assessed as not falling within Group A.

The Health Division is proposing a colour-coded system to be used for the proper segregation of clinical waste. Yellow bags are to be used for clinical waste for decontamination only and black bags are to be used for normal domestic waste. The treatment, which is being recommended, varies by the category of waste, namely:

- Group A waste is to be decontaminated;
- Group B waste is to be decontaminated and destroyed to remove its potential to inflict physical harm;
- Group C waste is to be autoclaved on site prior to disposal;
- Group D waste is to be collected and stored in an approved secure and audited location. Once certain volumes are accumulated, waste is to be processed using incineration or plasma thermal system. The possibility of exporting such waste is also being considered; and
- Group E waste is to be collected in black bags and disposed of as municipal waste except for Group E waste originating from patients infected with Risk Group 3 or 4 etiologic agents. The latter would then be treated as Group A waste.

The Clinical Waste Management Plan delineates specific procedures and practices to be adopted with respect to the storage, transportation, waste decontamination, training, monitoring and other administrative arrangements required for the storage and final disposal of clinical waste.

The Health Division envisages significant progress to be achieved in respect of the installation of the required equipment to dispose of clinical waste at the Mater Dei Hospital by the end of 2005. The facility that is being considered by the Health Division is one based on microwave technology. The Health Division aspired to close down the incinerator at St. Luke's Hospital way back in the year 2002. Indeed, the tendering process for a new facility was initiated in August 2000.

The tender was awarded in June 2002 for the installation of Sanitec Microwave System at St. Luke's Hospital. The tender process was halted in August 2003 following the inability of the supplier to deliver the equipment.

In the year 2004, the tendering process was reinitiated, this time for the installation of the new facility at the Mater Dei Hospital. A pre-qualification call was issued in May of this same year. The evaluation of twenty-six (26) proposals received started in June 2004. The process was once again brought to a standstill in January of the year 2005 due to an Appeal's hearing. The Health Division is currently awaiting a decision following this hearing.

03.7 Summary of Findings

The following Table provides a summary of the amount of waste generated by entity, the treatment being proposed and the status of the individual project.

Table 7: Summary of findings

Entity	Waste	Amount of Waste (tonnes)	Treatment Required	Status
WSC	Wastewater	2005: 8,800 2010: 46,650	Digestion	Initiated – discussions ongoing
Food & Veterinary Services Division	Animal by-products	19,590	Incinerator and/or facilities that convert by-products into recycled products.	Initiated
Animal Husbandry	Manure	450,000	Anaerobic digestion	Ongoing – Proposals by end of May 2005
Health Division	Clinical waste	2,400	New equipment at Mater Dei	Ongoing – tendering stage

04. Legal Backdrop

The accession of Malta to the European Union generated changes in many areas, particularly in the environmental legislation. This section provides an overview of the current legislative framework in Malta related to environment and renewable energy sources. However, an exact description of the contents of the individual directives will be abstained within this report, because the compliance with the legal framework forms an integrated element of the considerations being put forward.

EU Directives related to Energy

The directives that are of interest to this report are listed below.

- Directive 2001/77/EC

The aim of this directive is the promotion of renewable energy to contribute to the electricity generation by utilizing alternative sources.

- Directive 2003/54/EC

The main task of this directive is the introduction of competition in the electricity sector across all Member States and to promote further liberalization in the electricity sector through setting targets for the opening of markets.

EU Directives relating to the Environment

- Directive 96/61/EC (IPPC- Integrated Pollution Prevention and Control)

- Directive 2001/80/EC (LCPD- Large Combustion Plants Directive)

The directive 2001/80/EC applies to large combustion plants with a thermal output greater than 50 MW. The LCPD considers also advances in combustion and abatement technologies.

- Directive 96/62/EC

This directive defines the framework for ambient air quality and limit effects on human health and the environment.

- Directive 97/11/EC

The aim of the directive is to set out the requirement that the environmental impact of a project should be evaluated.

National Legislation

This section provides an overview of the current legislative framework in Malta related to the environment and waste management.

- Abandonment, Dumping and Disposal of Waste in Streets and Public Places or Areas Regulations, 2005 (LN 344/2005)
- Environment Protection Act of 2001 (Act XX of 2001)
- LN 128/1997 Deposit of Wastes and Rubble (Fees) Regulations
- LN 158/1998 Non-alcoholic Beverages (Control of Containers) Regulations
- LN 205/2000 Environment (Control of Transboundary Movement of Toxic and Other Substances) Regulations
- LN 212/2001 The Sludge (Use in Agriculture) Regulations
- LN 223/2001 Waste from the Titanium Dioxide Industry Regulations

- LN 336/2001 Waste Management (Incineration) Regulations
- LN 337/2001 Waste Management (Permit and Control) Regulations
- LN 338/2001 Supervision and Control of Shipments of Radioactive Waste Regulations
- LN 158/2002 Waste Management (Batteries and Accumulators) Regulations
- LN 161/2002 Waste Management (Waste Oils) Regulations
- LN 166/2002 Waste Management (Polychlorinated Biphenyls and Polychlorinated Terphenyls) Regulations
- LN 168/2002 Waste Management (Landfill) Regulations
- LN 98/2004 Waste Management (Packaging and Packaging Waste) Regulations
- LN 99/2004 Waste Management (End of Life Vehicles) Regulations
- LN 60/2000 Product Safety (Asbestos Labelling Regulations)
- LN 234/2002 Integrated Pollution Prevention and Control Regulations
- LN 204/2001 Environmental Impact Assessment Regulations

This overview reflects also the commitment Malta has made towards transposing EU Directives to Maltese law. The relevant and competent authority for this suite of environmental legislation is the Malta Environment and Planning Authority (MEPA).

05. Wastes Available for Conversion to Energy

Malta is totally dependent on the importation of oil for all its energy generation requirements. In the case of Malta, the connection of the island to continental European energy production networks would be technically feasible but not necessarily financially viable. Therefore, the most important goal for the future in Malta will be to increase the efficiency of the production and consumption of energy, whilst reducing air pollution, and to mobilize all efforts to utilize the island's present potential in renewable energy sources such as solar (e.g. photovoltaic), wind, biomass and energy from waste. New energy sources such as biogas, hydrogen, and the use of fuel cells must be tapped and our waste is the ideal "supplier" of the secondary raw materials.

The supply of "green" and affordable energy and a significant increase in the efficiency of consumption will be the major criterion for a sustainable development on the Island. The reduction of oil consumption for electricity generation and the gradual detachment from the dependency on fossil fuels are of crucial importance for the economy of Malta and the challenge for the next years.

05.1 Waste Composition

As a starting point the NSO survey of 2002 on the composition of the regional domestic waste composition was utilized, the basis of which is summarized hereunder.

- Total population (NSO 2003): **399,867**
- Average daily waste per household: **2.3 kg**
- Average daily waste per person: **0.68 kg**

The average waste composition in % (Malta, Gozo, Comino) as given in the NSO survey of 2002 is summarized hereunder.

- Plastic Containers: 5.07%
- Plastic Film: 4.50%
- Paper: 7.06%
- Organic Waste: 59.46%
- Glass Bottles: 3.96%
- Ferrous Cans: 3.39%
- Textiles: 3.28%;
- Hazardous: 2.71%;
- Others: 4.13%
- Cardboard/Cartons: 5.61%
- Aluminum Cans: 0.20%

05.2 Calculation of Amount of Waste Generated

The amount of waste generated was based on the following calculations:

a) 399,867 x 0.68 kg/day = 271,909.56 kg/day→ **99,247 tons/annum** MSW from households in 2002 (based on the NSO survey).

b) Composition:
- **59,012 tonnes per annum** organics from households;
- **5,032 tonnes per annum** plastic containers;
- **4,466 tonnes per annum** plastic films;
- **7,007 tonnes per annum** paper;
- **5,568 tonnes per annum** cardboard/cartons;
- **3,930 tonnes per annum** glass bottles;

- **3,365 tonnes per annum** ferrous cans;
- **198 tonnes per annum** aluminum cans;
- **3,255 tonnes per annum** textiles;
- **2,690 tonnes per annum** hazardous;
- **4,099 tonnes per annum** others

The total amount of MSW dumped at Maghtab and Zwejra was approximately 170,000 tons in 2004 (approximately 100,000 tons from households). Consequently, about 70,000 tons came from hotels/restaurants, food stores, small businesses, markets and hospitals (commercial and tourism sector). Assuming that the average organic content of the 70,000 tons is also about 59%, the theoretical exploitable organic content for biogas production from the total 170,000 tons of MSW would be around 100,000 tons. Waste characterisation tests at Malta International Airport, Le Meridien Phoenicia Hotel and Radisson SAS Hotel during 2002 support the assumptions regarding organic content.

05.3 Waste Separation and Recycling

To reduce the costs for waste separation, many countries in Europe implemented separation schemes for certain waste fractions like glass, paper/cardboard, ferrous materials and plastic successfully. In order to guarantee an economic and ecological success, a sufficient amount of recyclable products/ material is required.

The question whether recycling is relevant or not, can only be clarified, if the recycling process is compared with production methods where primary raw material is utilized. The energy and material consumption are to be taken into account for this exercise.

The segregated collection of glass, plastic and cans could be questionable, because the production for example of glass bottles out of used glass saves some raw materials, but burdens the environment with the expenditure by the transport (emissions), sorting, pretreatment (energy input) and water consumption in the reprocessing of the used glass.

Recycling is from an ecological point of view useful, if the accruing residues from collecting and reprocessing, the emissions, the required energy quantities and impacts to the environment are lower than the sum of impacts, that are accruing by manufacturing of products from primary raw materials with following dumping or combustion of the production process residues[7].

The above statement should **NOT** imply that “Bring-in-Sites” or “Civic Amenity Sites” are obsolete or useless. **It is the opposite**, because certain waste fractions are collected separately and can be utilized for recycling or thermal use virtually without pretreatment. Even some hazardous substances from households, which is very important for further treatment options (Mechanical-Biological-Treatment with following Anaerobic Digestion), could be taken out of the mixed MSW stream.

There is no doubt that the separate collection of glass, paper, plastics, ferrous cans and aluminum cans with subsequent recycling are a contribution to protect natural resources and to reach the recycling targets. Due to the absence of significant amounts of certain recycling streams and treatment facilities, Malta has to ship dry recyclables abroad, which causes additional costs for the waste management system on the Island.

05.4 Waste Management in Foreign Jurisdictions

Pretreatment of MSW is already a requirement in Germany and Austria for example, because dumping of untreated waste is not allowed anymore. New directives are already in force in these two member states and only waste below a certain calorific value can be dumped in an engineered landfill (calorific value 6000 kJ/kg). The high calorific fraction (calorific value beyond 6000 kJ/kg) has to be utilized thermally. Without pretreatment, the limiting value of 6000 kJ/kg is not achievable. Modern treatment plants provide already a high efficiency and the automated separation of MSW is not deemed to be a problem.

[7] Source: “Claus Bliefert - Umweltchemie”; 3rd revised edition 2002

Given that mechanical-biological pre-treatment of waste is already obligatory and the recycling targets may still be achieved the question remains whether segregation / separate systems and the different collection schemes are appropriate and financially meaningful.

In 2001 the Federal Office for Environment, Forestry and Landscape of Switzerland (BUWAL) presented a position paper on plastic recycling. RECYCLING means the reprocessing in a production process of the waste materials for the original purpose and the same product quality. This aim can only be achieved by separate collection of the different plastic kinds. The fabrication of products out of mixed plastics (DOWNCYCLING) would lead to products with inferior quality.

The total amount of plastic waste, which can be collected from households, is about 30,000t in Switzerland (in Malta approximately 8,200 tons/annum from households = 8.33% of the waste composition). The BUWAL of Switzerland came to the conclusion that the separate collection of plastic waste from households is economically not meaningful due to high costs and the minimal effects on the total volume of waste from households. This statement is supported by an additional survey by the Dutch Institute of Industrial Technology (TNO). This survey concludes that only the separate collection of PET-bottles (PET = Polyethylene Terephthalate; a crude oil product) from households is meaningful from an economical and ecological viewpoint.

Land is a very scarce resource in Malta and it is important to realize that dumping of untreated refuse is a waste of land, causes unpredictable burdens for future generations, is a waste of valuable raw material for recycling and a waste of the embedded energy.

05.5 Determination of MW-Potential of Waste

The determination of the calorific value is essential for the selection of the appropriate "Waste-to-Energy" technology.

5.5.1 Calorific Value

The upper calorific value is the gross energy content including the energy, which is necessary to evaporate the moist content. In practice, this value is relatively uninteresting for incineration, gasification or pyrolysis. The lower heating value is important, because this is the energy content, which can be utilized for the production of thermal and electrical power.

In 1980 Germany conducted a survey to determine the waste composition from households with the following results: 20% paper/cardboard, 12% glass, 7% plastic, 42% kitchen waste and 19% other waste. The average water content was between 30% and 40%. If these results are compared with Malta the main difference is the organic fraction. In Malta the average kitchen waste content is around 59% and consequently the water content will be higher (estimated ≈ 50%). The moisture has always a negative effect for thermal utilization. In order to guarantee an independent combustion (without auxiliary fuel) of mixed and moist MSW, the lower heating value should be beyond 7000 kJ/kg[8].

The determination of the energy value of waste is also possible by calculation of the energy potential of the different waste components. The formula for determining the calorific value of waste components is as follows:

$$[CV_{raw} = ((1-w) \times (CV_{upper} - (2441^* \times 9) \times H)) - 2441 \times w]$$ [9]

Where:

CV = calorific value ("raw" is real "as delivered" value, "upper" is value for dried material) in kJ/kg

w = % moisture content (by weight)

H = % Hydrogen content (from literature values)

***** vaporization enthalpy of water (2,441 kJ/kg at 25^o C)

[8]Source: "Weissbuch Thermische Restmuellbehandlung in Oesterreich"; Austrian Federal Ministry of Agriculture and Forestry, Environment and Water Management; 2001

[9] "Guideline for Determining the Renewable Components in Waste for Electricity Generation", Australian Government, Office of the Renewable Energy Regulator; March 2001

To determine the calorific value of a waste stream the following steps are carried out:

- Sample is sorted and analyzed into fractions;
- CV_{upper} is applied from known data (literature);
- CV_{upper} is analyzed for unknown fractions;
- % Hydrogen is applied from known data (literature);
- Moisture of fractions is determined; and
- Calculate values for CV_{raw}.

In 2004 a total of 295,000 tons of waste were collected in Malta (excluding some hazardous waste which is stored at various sites in Malta). From the total amount of waste, 170,000 tons is mixed MSW with the further above-mentioned composition. The remaining 125,000 tons (= 295,000 tons minus 170,000 tons MSW) are coming probably from the commercial and industrial sectors.

From this waste stream approximately 31,000 tons could be utilized in a waste-to-energy facility. The essential part is the bulky waste fraction with a calorific value similar or higher than MSW (8,000-11,000 MJ/ton).

The advantages for thermal treatment for this kind of waste are:

- Reduction of volume (≈ 90 %)
- Reduction of weight (≈ 70%)
- Render the waste inert
- Recover value from waste (mainly electricity/thermal power)
- Diversion of degradable solid waste from landfill
- Practical solution for the chronic shortage of landfill space

5.5.2 Theoretical Energy Calculations derived from MSW and Waste similar to MSW

These calculations are based on the assumption that 170.000 tons of MSW are utilized in a thermal treatment facility. The calculation of the energy potential by combustion of these 170,000 tons of MSW is solely for demonstrative purposes.

Calculation of the theoretical energy potential:

The calculation is based on the amount of 170,000 tons of MSW including waste similar to that generated from the commercial and industrial sectors and on an average calorific value of 9,500 MJ/t[10]:

$$170{,}000\,\frac{\mathrm{t}}{\mathrm{a}} \times 9500\,\frac{\mathrm{MJ}}{\mathrm{t}} = 1{,}615{,}000{,}000\,\frac{\mathrm{MJ}}{\mathrm{a}}$$

$$1{,}615{,}000{,}000\,\frac{\mathrm{MJ}}{\mathrm{a}} = 51.2\mathrm{MW}$$

The 51.2 MW is the thermal power embedded in the waste and is available for the production of electricity and heat. The following calculation highlights the potential for electricity production using this thermal power in a steam turbine.

Efficiency of a small steam turbine: ≈25% (90% availability)

$$51.2MW \times 25\% = 12.8MW$$

$$12.8MW = 102.4\,\frac{GWh}{a}$$

[10] Matthias Bank: "Basiswissen Umwelttechnik", 4th revised edition 2000

This calculation indicates that there is a huge energy potential, 102.4 GWh, in our waste, which is going to landfill at present. However, this example is only for demonstrative purposes, because the treatment capacity of such a facility would be 23 tons per hour, investment costs would amount to more than € 150 million with operating costs of around € 50-100 per ton. These figures do not include the additional costs for disposing of the slag and ash in a landfill. With conventional incineration the weight of waste is reduced by approximately 70 percent. Consequently 51,000 tons of slag and ash have to go to an engineered landfill. At first view, this seems to be an acceptable solution, because the energy output is fairly high. Due to the reason that land is the scarcest resource in Malta, a conventional thermal treatment plant may cause unpredictable problems for future generations and the incineration of non-separated MSW should not be promoted under a future support system for renewable energy sources (Directive 2001/77/EC) despite reducing landfill requirements by 90%.

The European Commission set a provisional target of 5% (3% by waste) of renewable electricity generation, expressed as a percentage of demand, to be met by 2010. The following table shows the energy potential of sewage sludge, hospital waste and animal husbandry waste calculated using similar method (utilization in a thermal treatment facility) to that highlighted above. The calorific values for the calculations are taken from literature and are intended to present an overview of the energy potential of these waste streams.

Waste fraction	Amount per annum	Calorific value	Theoretical "renewable" energy potential	Percentage of the electricity generation of EneMalta in 2003[11]
Sewage sludge (dry substance)	≈10,000 tons	17,000 MJ/t	10.8 GWh	0.5%
Hospital waste	≈2,000 tons	14,000 MJ/t	1.8 GWh	0.09%
Waste oils (engine, gear and lubricating oils)	No reliable data available	43,200 MJ/t		
Animal husbandry waste (dry substance)	≈102,000 tons	13,000 MJ/t	84.1 GWh	4.1%
MSW	≈ 170,000 tons	9,500 MJ/t	102.4 GWh	4.9%

The theoretical energy potential of these four waste streams is 199.1 GWh and this would be a contribution of **9.6%** based on the electricity generation in 2003. In conclusion, the calculations indicate that there is a considerable unexploited amount of energy in our waste and the overall renewable energy target of 5% would be achievable only by an efficient utilization of waste.

[11] The electricity generation of EneMalta was 2,070 GWh in 2003.

06. Overview of Waste to Energy Processes

The main objects of the processes under consideration are the:

- o extraction of the maximum amount of energy from the available waste and its conversion to electricity;
- o reduction of the bulk of the waste to the minimum possible; and
- o respect for the environment by the prevention of the emission of dangerous substances into the atmosphere and into other waste streams.

The production of heat without conversion to electricity has limited use in Malta. In colder countries waste to energy plants often provide district heating, where hot water is piped to homes within a limited radius to supply central heating. Heat may also be needed for certain industrial processes. Such use is limited in the local context, unless a particular heat using industry happens to be in the immediate vicinity of the plant. A possible way of utilising the waste heat is for the production of fresh water by distillation of sea water. District heating is also of limited use as it will only be saleable for a short time during the year.

The provision of communal cooling would appear to be more attractive, but the implementation of such a process on a large scale is still not an established technology, especially where the source of energy is waste heat.

It is therefore processes which produce or make possible the production of electricity which merit consideration. The various processes available can be compared to one another according to their capacity to produce electricity.

06.1 The Combustion Process

Combustion of solid fuels is a complex chemical process consisting mainly of the following components:

1. **drying and degassing***:* here the volatile content of the fuel (such as hydrocarbons and water) is evolved. This requires the supply of heat and occurs at temperatures of 100 to 300^{0}C.
2. **pyrolysis**: This is the further decomposition of organic substances in the absence of oxygen at temperatures of 400-700^{0}C.
3. **gasification***:* Here the solid matter is transformed into the gaseous phase by the combination of the organic matter with oxygen and water vapour at temperatures between 700 and 1000^{o}C.
4. **oxidation***:* The combination of the gases from the previous state with oxygen, at temperatures generally between 800 and 1400^o, depending on the particular process

06.2 Waste to Energy Processes

Incineration is a complete system where waste material undergoes the whole combustion process to extract all the heat energy in the wastes. There are various types of incinerators differing in waste pre-treatment requirements and in the manner in which they burn waste. They fall into two broad categories, namely, mass burn incinerators and 'other type' incinerators including fluidised bed, cyclonic, rotary kiln, rocking kiln, starved air and liquid and gas burning incinerators[12]. The choice of incineration system depends not only on the combustibility of the waste but also on its other characteristics, e.g. physical state (i.e. whether liquid, sludge, solid, or gas), chemical composition, stability and toxicity

[12] A cement kiln is another type of incinerator which may use MSW as additional fuel.

In a waste to energy incineration plant the heat produced is typically used to produce high pressure steam which is then used to produce electricity in a turbine generator set.

Technologies alternative to incineration carry out the function of waste to energy conversion by converting the waste to a form of fuel which can then be utilized in a manner which has advantages over direct incineration. Such technologies may also utilize only part of the energy inherent in waste and preserve part of the waste stream in a form suitable for recycling.

Pyrolysis is the thermal degradation of organic waste in the absence of oxygen to produce a carbonaceous char, oils and combustible gases. Relatively low-temperatures are used in the range 400 to 800^oC. The relative proportions of these pyrolysis products depend on the technology used and the process parameters, mainly temperature and heating rate: very slow heating rates and low final temperature yields mainly char (e.g. charcoal from wood); conventional pyrolysis uses moderate heating rates and maximum temperatures of about 600^oC and generates approximately equal distribution of char, oil and gases. Very high heating rates (100 to 1000 ^oC/second) at temperatures below 650^oC with rapid quenching (flash pyrolysis) yields mainly liquid products. High heating rates and high final temperatures yields mainly gases. The pyrolysis-derived oils have a much higher energy density (energy per unit mass) than the raw waste and the char can be used as a solid fuel or as a char-oil (char-water slurry for fuel) or it can be upgraded for use as activated carbon. The gases generated have medium to high calorific values and may contain sufficient energy to supply the energy requirements of the pyrolysis plant.

Pyrolysis of RDF from municipal waste produces a char with ash content of about 37% and a calorific value of about 19 MJ kg^{-1} which compares favourably with that of bituminous coal (30 MJ kg^{-1}); however, the high ash content detracts from the value of MSW-char as a fuel..

A pyrolysis plant is associated with preparatory sorting and conditioning processes. The resulting gas is cleaned and sometimes mixed with natural gas and used as a fuel for gas engines or gas turbines to produce electricity. The coke may be used as RDF (Refuse Derived Fuel) and burned either alone or mixed with coal in a boiler to produce steam for electricity generation.

Gasification differs from pyrolysis in that oxygen in the form of air (20% O_2), steam or even pure oxygen (O_2) is allowed to react at high temperature with the available carbon in the waste to produce a mixture of gases, a tarry product and an ash. The operating temperatures are higher than those in pyrolysis (up to 1400^OC when oxygen rather than air is used) and the gaseous fuels obtained have medium calorific values (10 – 15 MJ m^{-3}). The gaseous fuels obtained from gasification of waste consist of a mixture of carbon monoxide, carbon dioxide, hydrogen and methane; where air gasification is used nitrogen is a main component and this lowers the calorific value to about 4 – 6 MJ m^{-3}. Tars also form during the gasification process as side products, their amounts depending on the technology used.

In contrast with pyrolysis, the solid residue is a slag with no energy value. Pure oxygen is used in the gasification process to improve performance, and the process may be carried out at high pressures to produce a gas, known as syngas, which can be utilized in gas turbines or engines for energy production. For these applications the gas has to be cleaned to a high specification to avoid fouling.

The Plasma Process is the treatment of wastes by subjecting them to a very high temperature (5000 to 15 000^oC) in an electric arc where the wastes are broken down into their atomic constituents which recombine in a gas which can be utilized in a power generation process. The solid residue produced is in the form of a glassy slag which is inert and of greatly reduced volume.

While the purpose of this study is to consider general waste to energy processes, there are also processes which have specialised uses in the processing of toxic wastes or other specialised wastes such as medical wastes and sewage wastes. The main object of these processes is the safe processing of the wastes and its conversion into a non toxic form. The resulting product may then be treated with general wastes in another process which produces usable energy. Table 2 gives a summary of thermal treatment techniques used in the treatment of various waste types.

Table 2 – Summary of Thermal Treatment Techniques

Technique	Untreated Municipal Waste	Pretreated MW and RDF	Hazardous Waste	Sewage Sludge	Clinical Waste
Grate – reciprocating	Widely applied	Applied	Not Normally Applied	Not normally applied	Applied
Grate – travelling	Applied	Applied	Rarely applied	Not normally applied	Applied
Grate – rocking	Applied	Applied	Rarely Applied	Not normally applied	Applied
Grate – Roller	Applied	Applied	Rarely Applied	Not normally applied	Applied
Grate – Water cooled	Applied	Applied	Rarely Applied	Not normally applied	Applied
Grate plus – Rotary kiln	Applied	Not normally applied	Rarely Applied	Not normally applied	Applied
Rotary kiln	Not normally applied	Applied	Widely Applied	Applied	Widely applied
Rotary kiln – Water cooled	Not normally applied	Applied	Widely Applied	Applied	Widely applied
Static Hearth	Not normally applied	Not normally applied	Applied	Not normally applied	Widely applied
Static Furnace	Not normally applied	Not normally applied	Widely applied	Not normally applied	Applied
Fluid bed - bubbling	Rarely applied	Widely applied	Not normally applied	Widely applied	Not normally applied
Fluid bed – circulating	Rarely applied	Widely applied	Not normally applied	Widely Applied	Not normally applied
Fluid bed - rotating	Applied	Applied	Not normally applied	Applied	Applied
Pyrolisis	Rarely Applied	Rarely Applied	Rarely Applied	Rarely Applied	Rarely Applied
Gasification	Applied	Rarely applied	Rarely applied	Rarely applied	Rarely applied

Note: This table only considers the application of technologies described at dedicated installations. It thus not therefore include detailed considerations of the situations where more than one type of waste is processed.

06.3 Summary of the current successful application of thermal treatment techniques to the main waste types at dedicated installations *(Source - BREF on Waste Incineration)*

6.3.1 Incineration technologies

Incineration is a mature technology and is used extensively in European countries for the conversion of municipal waste to energy. It is estimated that installed waste incineration plant in Europe and the US have a total installed capacity of over 5000 MWe producing some 220TWh of electricity per year.

The most popular type of waste incineration technique is the grate or mass burn incinerator. This is a furnace in which the waste is spread over the grate at the bottom of the furnace. The grate consists of a continuously moving cast iron chain or rocking sections. Air is blown from below the grate and flows up through a layer of ash and the waste, which burns as a continuous flame. It is estimated that the waste burns for 45 to 50 minutes while the flame residence time or the vapours generated is 2 to 4 seconds. The waste material is introduced through a hopper at one end of the furnace while at the opposite end the ash is discharged (this is termed bottom ash as distinct from fly ash which is removed at the precipitator).

Enhancements of the system include overfire air and flue gas recirculation which assist in the complete combustion of the waste and the elimination of undesirable substances in the exhaust gas.

The hot gases produced flow through various passes to release their heat to boiler tubes which use it to convert water to steam at high pressure for use in a steam turbine to produce electricity.

Gas cleaning devices are an important part of the system since the exhaust gas contains toxic components resulting from the composition of the waste and from the combustion process. The cleaning devices vary with different installations and include electrostatic precipitators, fabric filters, spray absorbers, scrubbers, activated coke filters, catalytic converters and SNCR (selective non catalytic reduction of NOx). Following the passage through these cleaning devices the exhaust gas issues through the chimney.

The system from the feeding of the waste material is fully automated. The temperatures at the furnace are over 1000^{o}C. This ensures that the waste materials are totally combusted. It is claimed that persistent organic pollutants such as dioxins, furans and polyaromatic hydrocarbons are thermally destroyed and the non combustible materials are mineralized into inert bottom ash and fly ash.

The resulting ash has only 10% of the original waste volume. Scrap iron is removed from the bottom ash which is then suitable for road construction and other construction processes. If disposed of in a landfill the ash does not pollute the soil, the groundwater or the air. Fly ash, the portion of the ash which is removed from the exhaust gas in the electrostatic precipitator and bag filter, constitutes only between 2 and 3% of the weight of the original waste matter. This contains most of the inorganic pollutants and thus has no recyclable value.

A plant burning 200 000 tons of municipal solid wastes per year, which is a suitable size for treating the waste produced in Malta, is estimated to have a footprint of 20 000 m^2, with a building height of 45-50m and a chimney of 60-80 m. The electricity generated will be between 10 and 15 megawatts, which represents 5% of Malta's electricity needs. The ash produced from 600 tons of waste per day will be equal to 150 tons of bottom ash and 15 tons of fly ash. It is estimated that such a facility will have a capital cost of 120 to 200 million Euro.

6.3.2 Fluidised bed incinerators

An alternative to the grate incinerator is the fluidized bed system, where the wastes are mixed with ash, sand and limestone to form a bed at the bottom of the furnace. Air is bubbled through the bed and the turbulence causes the bed to fluidise, that is, to behave as a fluid. Combustion occurs inside the fluidized bed at a lower temperature than in an open flame, and this prevents the formation of NOx, while sulphur dioxide is absorbed by the limestone. Flue gas is also recirculated through the bed. This mode of firing reduces the requirement for gas cleaning.

The system is more complex than that of the grate incinerators and needs preparatory shredding of the waste material before charging into the furnace. While a maximum size of shredded material is limited, installations exist where up to 95% waste at 300mm maximum is acceptable (e.g. the 100 000 ton/year incinerator at Niklasdorf in Austria). The system is used widely for the incineration of sewage sludge or RDF, where the need for complex preparation is eliminated. Fluidised bed waste incinerators are popular in Japan where there are over 150 installations with a typical capacity of 50 to 150 tons per day.

6.3.3 The rotary kiln incinerator

This is basically a rotating inclined cylinder, with the waste charged at the high end and burned while moving towards the lower end, where it may be further treated in a secondary combustion chamber.

This type of incinerator accepts a wide variety of wastes without the need for preparation and is used widely for the incineration of hazardous wastes such as clinical wastes. Rotary kilns for municipal solid wastes are usually between 10 and 15 meters long, and 2 to 5 meters in diameter, and rotate slowly to facilitate the transport of the waste. The post combustion chamber provides residence time for the flue gases produced during incineration. Gas cleaning devices after incineration are similar to those in a grate incinerator. This type of incinerator requires considerable maintenance and is mostly used in smaller sizes.

6.3.4 Gasification and Pyrolysis Technologies

Processes using gasification are designed to minimize emissions by treating the waste in a succession of processes such that open combustion does not occur.

In a process described in the request for information, the waste is first treated in an autoclave, where the waste is subject to steam under pressure in a rotating drum where the food and paper waste are converted into a pulp while the metals are cleaned. The sterilized waste is separated automatically into pulp, metals and rigid plastics and glass and grit are removed by washing. The pulp is then dried and transferred to the gasification / pyrolysis) vessel where it is subjected to heat and converted to syngas, which is a gas consisting of methane, hydrogen, carbon monoxide, and carbon dioxide. Part of this gas is used to fuel the gasifier and the rest is used in a gas engine or gas turbine to produce electricity.

It is claimed that up to 90% of the household waste is diverted from landfill. Autoclaving sterilizes the waste and in a demonstration installation, 100 tons of mixed waste yielded 3-5 tons of clean ferrous metal, 1-1.5 tons of clean non ferrous metals (separation efficiency better than 95%), 1 ton of clean PET plastic containers, 10-12 tons of mixed glass and grit, suitable as a secondary aggregate in construction, 40 tons of dry homogenized organic pulp, suitable for energy recovery, and 40 tons of nutrient rich effluent, which can be treated by anaerobic digestion for recovery of water for industrial and agricultural uses.

The dry organic pulp has an energy content of 22GJ/ton and 10% ash content. Using the best available technology an energy recovery of 550-600 kWh per ton of MSW is claimed.

6.3.5 Application of the Gasification technology in Malta

The RFI resulted in the receipt of a proposal for the use of the technology in Malta. It was proposed to apply the technology in stages, in order to attain the 2008 target date.

Initially a number of autoclave units will be installed, each with a capacity of up to 10 tons per hour, for treating the MSW. This will enable automated sorting of recyclable waste and produce RDF (refuse derived fuel) in the form of pulp. The second stage will be the installation of gasification units to produce syngas from the pulp, and gas engines to use the syngas to produce electricity. An estimated 12MW of continuous electricity output can be supplied.

The location would either be a barge 110m x 63m x 5m, with a maximum height of up to 12 meters with a chimney height not exceeding 15 m from deck level. Alternatively a land based installation would require a footprint of 2.5 ha with a maximum building height of 15m.

Considering a 100 000 ton per annum plant, the capital cost is estimated to be Lm12-14 million for a marine unit and Lm 16-22 million for a land based unit. Land acquisition cost is not included. This figure is unstatistically low and is not supported by actual commercial operational as only demonstration of this system exist to date.

The residue from the gasification plant is mineral ash with a content of unburnt carbon estimated at 50%. Emissions to the air arise from the exhaust of the gas engines and are treated using the technology appropriate to such engines.

6.3.6 Autoclaving technology

The treatment of waste in an autoclave and the subsequent separation of the metals and recyclable plastics, together with the treatment of the organic pulp produced by drying was proposed. This is described above as a preliminary to the gasification process. While the product of autoclaving can be used as fuel, autoclaving by itself is not a waste to energy process.

6.3.7 High Temperature Gasification Process

The High Temperature Conversion of Waste (HTCW) technology is a new technology where waste is continuously fed into a large vertical reactor. As the feed material descends in the reactor it passes through successive zones of drying, pyrolysis and oxidation, the latter process involving the addition of oxygen and steam and operating at a temperature of 2000^0. A reduction zone converts metal oxides to native metal. The process produces syngas, metals and vitrified slag.

It is claimed that no ash and flue gases are produced and the syngas is free of dioxins. The syngas is used as a fuel for gas engines or gas turbines, and the exhaust from these engines is treated in the conventional method.

This process has been used in a demonstration plant in Germany and is still not in general use. Indicative capital costs for a 40,000 ton/year unit are €48 million. The plant has a footprint of $40{,}000m^2$. The production of electricity per ton of waste is not clear.

6.3.8 Plasma technology

In this technology the waste material is fed into the reactor where it is subjected to a plasma arc at a temperature of about 8500^0, at which temperature the molecules of the material dissociate into elementary particles to reconstitute into simple elements. The products are a gas known as PCG which is rich in hydrogen and carbon monoxide. The other by product is an obsidian like slag which is non leachable.

Because of its capacity to dissociate all chemical compounds the process is used for the destruction of hazardous wastes including chemical and biological weapons. However it is yet to gain acceptance for use in municipal waste to energy processes.

6.3.9 Biological waste treatment

Wet and dry digestion systems produce compost and biogas. Anaerobic digestion is the microbiological degradation of organic material in the absence of oxygen. This results in the production of 'biogas' or 'landfill gas', a mixture containing approximately 60% methane and 40% carbon dioxide. Anaerobic digestion can be used to produce energy from waste streams of natural materials or to lower the pollution potential of a waste stream.

Anaerobic digestion has been used to treat sewage sludge and agricultural wastes for many years; its application to MSW and industrial wastes is a more recent development[13]. The process takes place in an enclosed, closely controlled reactor. Factors which require control are pH of waste, nutrient content and the carbon:nitrogen (C:N) ratio of the waste feed stock. High C:N ratios as are associated with MSW may lead to lower methane production: co-digestion with sewage sludge would be one method of decreasing this ratio since this sludge is rich in protein (high in N content).

The solid residue from anaerobic digestion can be matured into a compost product. This still has a high energy value, so that it is only a minor proportion of what is available is converted to usable energy, which may be considered as a bye product of the composting process.

Mixed MSW would require sorting to remove the non-digestible fraction such as metals and plastics so that the plant would require a mechanical treatment plant as a front end component.

6.3.10 References

Besides the information supplied following the Request for Information, the information in this section was mostly obtained from the document "Draft Reference Document on Best Available Technique for Waste Incineration", published by the European Integrated Pollution Prevention and Control (IPPC) Bureau of the EU. It is one of a series of BREF's, which are documents to be used in connection with the IPPC Directive 96/61/EC. The document may be downloaded from the website http://eippcb.irc.es. Another useful website is that of the United Nations Environment Programme on Waste Management at http://www.unep.or.jp/ietc/ESTdir/Pub/MSW.

[13] The Valorga (Amiens, France) anaerobic digestion plant was built in 1988 to treat over 100 000 t/y of mixed MSW and 5000 t/y of industrial waste and produces 131 m^3 of gas per tonne of sorted waste.

07. Available Options

Malta is hundred percent dependent on the importation of oil for the generation of electrical energy. The rising price of oil has caused global ripples to which Malta is no exception. Consequently, alternative energy sources such as biogas, hydrogen and the use of fuel cells must be tapped into and the potential to recover energy from waste must no longer be neglected. The heating value of one ton of MSW amounts to approximately 8,000 to 11,000 MJ and this heating value corresponds to the calorific value of 250 liter of fuel oil[14].

The amount of waste generated is on the increase whilst the land resource for landfills is very limited in Malta. Therefore whilst attempting to reduce the amount of work generated it is equally necessary to optimize the recovery of resources and energy from waste, whether through recycling (e.g. metals, plastics, paper, cardboard) mechanical-biological treatment (including anaerobic digestion) and efficient thermal utilization processes. The exploitation of the residues of our consumer society for the production of renewable energy or alternative fuels is an important forward-looking state of the art waste management strategy.

Energy from waste is an alternative energy source and can have a positive impact within an environmental context for the following reasons[15]:

1. Certain sorted waste has a high calorific value. Power generated from mixed plastics waste, for example, represents a calorific value similar to coal.

2. Energy from waste directly saves fossil fuels and makes an important contribution to the reduction of EU dependency on foreign imports. It is estimated that just 10% of presorted EU municipal waste would cover 5% of EU energy needs per year.

3. Energy from waste reduces overall greenhouse gas emissions in two ways. Firstly, it avoids methane and other emissions from waste disposed in landfill; methane is a particularly potent gas with at least 21 times the impact on global warming than CO_2 (the half-lifetime period of methane in the atmosphere is 12 years); secondly, energy from waste can generate, when presorted, 29% lower CO_2 emissions than, for example, a coal power station. An analysis of CO_2 equivalent emissions per kWh of electricity produced by energy from waste showed that in the system studied, the net global warming potential of the energy from waste option was less than coal, fuel and natural gas.

4. Energy from municipal solid waste already contributes to 3% of EU electricity production from renewable energy sources. Furthermore, the overall emissions from thermal municipal waste treatment facilities – which must now comply with the strictest environmental standards – compare well to gas power stations, which are usually considered to be one of the cleanest technologies. Energy from waste is a secure energy supply. While not strictly renewable, it is nevertheless an ongoing and secure source, as waste generation is a constant byproduct of all human and industrial activity.

The products of the modern consumer society comprise an immense variety of different materials and substances, which can cause harm to the environment. For example one litres of grease-oil is able to contaminate one million (**1,000,000**) litres of water. The aim of a sustainable waste management is the treatment and handling of waste in a way that harmful substances are transformed into recyclable materials, completely harmless chemically, less reactive, water-insoluble and incombustible residues.

[14] "Thermische Restmuellbehandlung in Oesterreich"; Bundesministerium fuer Umwelt, Jugend und Familie; Wien 1999
[15] "Energy from Waste Fact Sheet"; www.assure.org, viewed 17/03/2005

There is no single waste treatment option that is able to deal with all kinds of waste generated. The **combination** of a selection of different **technologies based on local conditions, infrastructure and waste composition** ensures an optimal result. The aim should be the reduction of waste as much as possible and then to divert the remaining residues for recycling, mechanical, biological and thermal treatment with efficient energy and resource recovery.

07.1 Characteristic of Waste Generated

The knowledge of the amount and composition of waste is the most important information for the identification of the most suitable waste management systems. The waste composition is dependent on the economical structure, the community structure, the standard of education and the climate.
The relevant waste sources in Malta are:

1. Households
2. Construction and building industry
3. Institutions, trade/commerce and offices
4. Agriculture
5. Industries
6. Power plants
7. Quarrying
8. Wastewater treatment plant(s)
9. Waste treatment plant

The breakdown into waste streams is necessary to set strategic objectives for certain waste streams as well as to determine the future treatment methods and facilities required. The relevant waste streams are:

- Municipal waste
- Construction and demolition waste including excavation waste
- Animal husbandry waste
- Used tyres
- Packaging waste (e.g. paper, cardboard, textiles, metals, glass, plastics)
- Hazardous waste (e.g. sludge, waste oils, batteries, solvents, pharmaceuticals)
- Health care waste (e.g. hospital waste)
- End of life vehicles
- Sewage sludge
- Electrical and electronic equipment waste (e.g. computers, TV, mobile phones)
- Waste oils
- Slaughterhouse waste (abattoir)

Malta has approximately 400,000 inhabitants (399,867; NSO 2003) and the average waste amount per capita per day was estimated to reach 0.68 kg in 2002. The total amount of waste generated in 2004 was 295,000. From this quantity approximately 170,000 or 58% was municipal solid waste (EWC 20 03 01). This waste stream includes probably waste from hotels/ restaurants, the kitchen waste of hospitals, some commercial waste and residues from the Sant Antnin Waste Treatment Plant.

The potential waste streams for the production/recovery of renewable energy and value from waste in Malta are:

- Municipal waste
- Animal husbandry waste

- Used tires
- Hazardous Waste (e.g. sludge, waste oils, batteries, solvents, pharmaceuticals)
- Health care waste (e.g. hospital waste)
- Sewage sludge
- Waste oils.

07.2 Available Technological Solutions applicable for Different Waste Streams

7.2.1 Mechanical – Biological Treatment

The process and its possible combinations to meet different objectives is driven by legislation (e.g. Landfill Directive), markets for the products (e.g. glass, plastic, metal, electricity, heat, RDF..) and geographical constraints. The two elements of waste treatment, the mechanical and biological stage, can be combined in various ways to meet certain objectives like the recovery of resources (e.g. recovery of dry recyclables by mechanical separation of MSW), the production of a high grade compost or soil conditioner (quality depending on the input material), the stabilization of the material that will ultimately be directed to landfill, the maximization of biogas output for the generation of electricity or heat and the production of RDF (Refuse Derived Fuel).

With the exception of the stabilization of waste for landfilling, all objectives are applicable and useful for Malta.

The potential waste streams for the mechanical-biological treatment in Malta are:

- MSW;
- animal husbandry waste (e.g. manure, dung, pig slurry);
- sewage sludge; and
- some commercial waste similar to MSW.

7.2.2 Anaerobic Digestion

The process for the treatment of waste in an anaerobic digester is mostly used for the biodegradable fraction of MSW, animal husbandry waste and sewage sludge. The primary objective of this technology is the diversion of biodegradable waste from the landfill. The production of electricity by utilizing the biogas in a gas engine is an efficient option to recover energy from waste.

The potential waste streams are:

- animal husbandry waste (e.g. manure, dung, pig slurry),
- sewage sludge; and
- the biodegradable fraction of MSW.

7.2.3 Thermal Waste Treatment Technologies

Incineration with its different technological applications (grate firing, rotary kiln, fluidized bed) including energy recovery is by far the most widely used technology. The annual amount of energy generated in 2000 from incineration was estimated to be equivalent to the electricity demand of Switzerland[16]. Standard incineration systems have a poor public perception and other thermal treatment options, the so-called “Novel- Technologies”, are pushing for their share on the waste treatment market. These “Novel-Technologies” are pyrolysis and gasification. The term “Novel-Technologies” is a little bit misleading, because the principle of pyrolysis and gasification is hundreds of years old, whilst only the application for thermal waste treatment is relatively new, but with computer control technology the

[16] ”Energy from Waste Fact Sheet“; www.assure.org, viewed 17/03/2005

process is stable and reliable. However novel technologies have to date achieved little market penetration compared to thermal technologies, and are limited mostly to demonstration projects.

The pretreatment (size reduction by shredding) of waste is nearly not necessary for grate firing and rotary kiln systems. In case of fluidized bed combustion size reduction by shredding is required[17].

The potential waste streams are:

- Municipal waste
- Animal husbandry waste
- Used tires
- Hazardous Waste (e.g. sludge, waste oils, batteries, solvents, pharmaceuticals…..)
- Health care waste (e.g. hospital waste)
- Sewage sludge (dry matter content at least 35%)
- Waste oils

The treatment of all our waste streams with standard incineration systems is technically possible, but there is no system on the market, which is equally well suited for all different kinds of waste. Due to the very limited knowledge about the amounts of the different present and future waste fractions, the chemical composition and the physical properties of other waste streams the planning of such an installation needs to be treated very carefully.

7.2.5 Pyrolysis, Gasification

Pyrolysis and gasification, like incineration, are options for recovering value from waste by thermal treatment. The basic technology concepts are not novel but, recently, several new proprietary processes have been developed[18].

Both pyrolysis and gasification turn wastes into energy rich fuels by heating the waste under controlled conditions. Whereas incineration fully converts the input waste into combustion products and energy, these processes deliberately limit the conversion so that combustion does not take place directly. Instead, they convert the waste into valuable intermediates that can be further processed for material recycling or energy recovery[19].

Pyrolysis and gasification offer more scope for recovering products from waste than incineration. The only practical product of a standard incineration system is thermal and electrical energy, whereas the gases from pyrolysis and gasification can be used as a fuel and, after purification, as a feedstock in the chemical industry and other applications. The syngas of a gasification plant is rich in hydrogen and carbon monoxide and could be used as a feedstock to produce hydrogen or methanol and these products could be an increasing valuable resource in current oil price scenarios. The combination with a fly ash melting system (vitrified slag) could be meaningful. Although the operational reliability is not fully clear for all marketed systems, there are more than 100 facilities operating or ordered around the world and some plants have been operating commercially for more than five years[20].

The potential waste streams are:

- Municipal waste
- Animal husbandry waste
- Used tires
- Hazardous Waste (e.g. sludge, waste oils, batteries, solvents, pharmaceuticals)
- Health care waste (e.g. hospital waste)

[17] "State of the Art for Waste incineration Plants"; Federal Ministry of Agriculture and Forestry, Environment and Water Management; Austria, September 2002
[18] JUNIPER; www.juniper.co.uk, viewed 22/03/2005
[19] "Pyrolysis and Gasification Facts Sheet", JUNIPER; www.juniper.co.uk, viewed 09/03/2005
[20] "Pyrolysis and Gasification Facts Sheet", JUNIPER; www.juniper.co.uk, viewed 09/03/2005

- Sewage sludge

The pretreatment and preparation of the different waste streams is absolutely necessary. The modular design and the possibility to operate these facilities in a smaller scale (e.g. 3tonnes/hour) would enable the treatment of the different waste streams in separate thermal lines inside one facility. However, the prerequisite is the knowledge of the chemical composition and physical properties of the waste to be treated.

07.3 The Way Forward

The total amount of waste generated in 2004 was in the range of 295,000 tons. This quantity corresponds to the waste generation of a medium sized town in central Europe. However, a patented solution with a single technology approach is probably not available, not advisable and due to the relatively small quantities of the individual waste streams not essential. In this figure the amount of sewage sludge, agricultural waste (animal manure, dung, pig slurry) and hazardous waste is not included. The treatment of sewage sludge usually takes place at the sewage treatment plant (anaerobic digestion with biogas production and following electricity generation with the excess heat from the biogas engines can be used for drying of the sludge). The WSC has indicated that the amount of sewage sludge will be in the region of 10,000 tons per year.

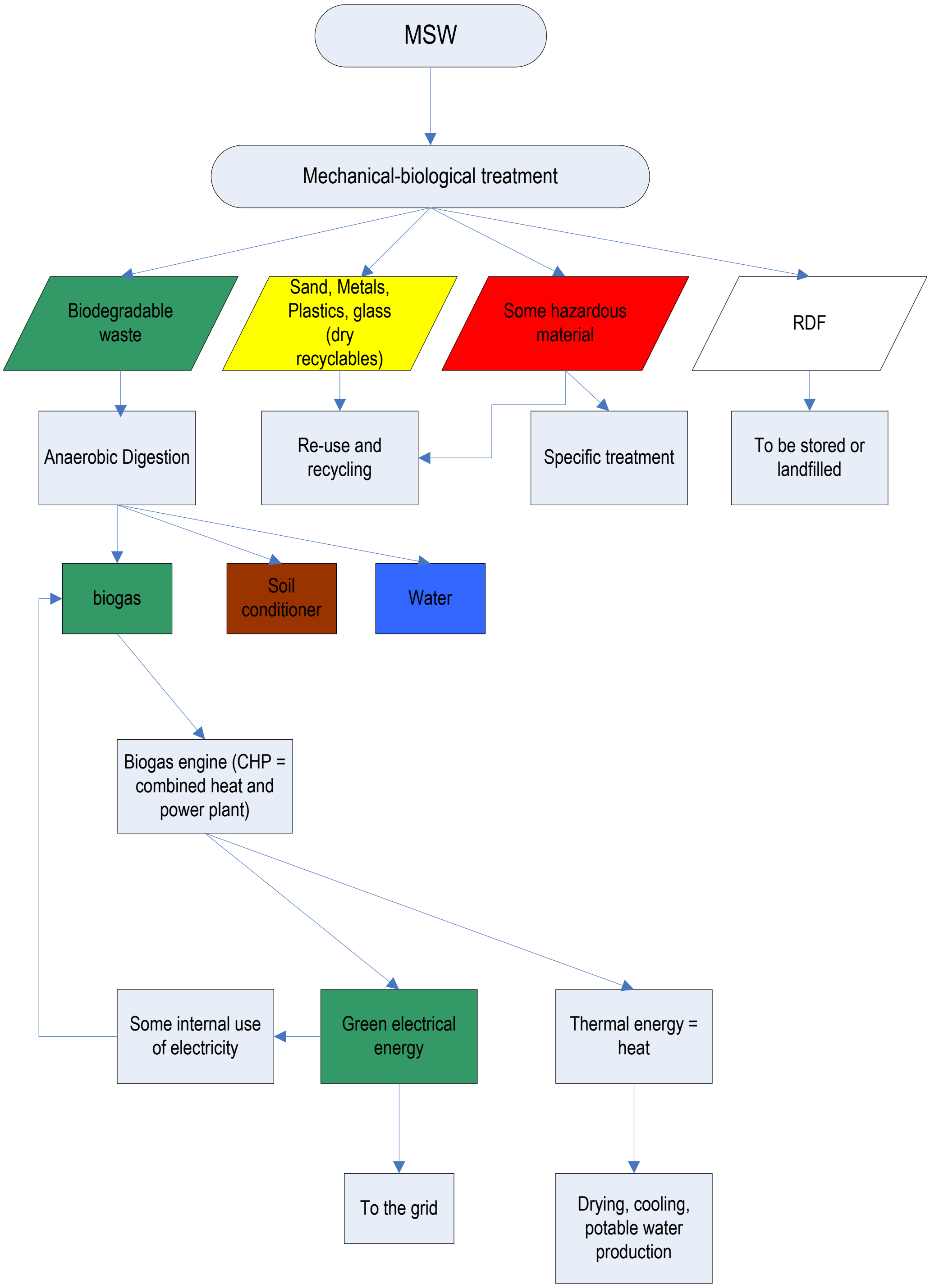
The exact amount of hazardous waste is not known. Due to the absence of heavy and chemical industries the total amount is not anticipated to be too dramatic and the appearance of heavy toxic and dangerous substances in a large quantity (several thousands tons) is not very likely. Therefore hazardous waste is a subordinate problem for the moment.

In order to cater for our waste streams in an integrated and sustainable manner, possible scenarios are now illustriated in more detail with respect to the legal requirements of the Landfill Directive. The possibility of disposing the waste in a landfill without any treatment, the previous and current practice, is not an option due to future legal requirements and in view of sustainable waste management practice.

The aim of the Landfill Directive is the reduction and diversion of the biodegradable waste fraction of MSW from the landfill within a certain timeframe. The biodegradable waste going to landfill in 2010 shall be reduced to 75% (= 66,675t) of the total amount by weight of biodegradable municipal waste produced in 1995 and buy 2013 this shall be further reduced to 50% (= 44,450) and by 2020 further reduced to 35% (= 31,115t).

The reduction/diversion target can be achieved with mechanical-biological treatment, thermal treatment or a combination of both. The combination of the two stages of a mechanical-biological treatment process can be used to separate and stabilize the waste for landfilling or for the production of alternative fuels (RDF) for thermal treatment. In Malta it is of utmost importance to divert as much waste as possible from the landfill, to utilize it for energy recovery and to minimize the amount of residues.

Scenario 1: Schematic description of the improvement of the Sant Antnin Waste Treatment facility



Environmental Benefits

The salient benefits of this scenario are the following:-

- Fulfillment of the first stage of the Landfill Directive in 2010
- Contribution to the recovery and recycling targets by mechanical separation
- Diversion of some hazardous waste from the landfill
- Production of biogas which is an alternative renewable, “green” fuel and energy source
- This solution is a net energy producer (contribution to the renewable energy target)
- Saving of fossil fuels
- Production of renewable thermal and electrical energy
- Reduction of GHG =Green House Gases (Biogas is CO_2 neutral)
- Efficient treatment of biodegradable waste through anaerobic digestion
- Flexible treatment solution
- Tailor-made preparation of different waste fractions for anaerobic digestion and thermal treatment
- Possibility to limit the landfill fraction to less than 15% in the form of inert components

Disadvantages

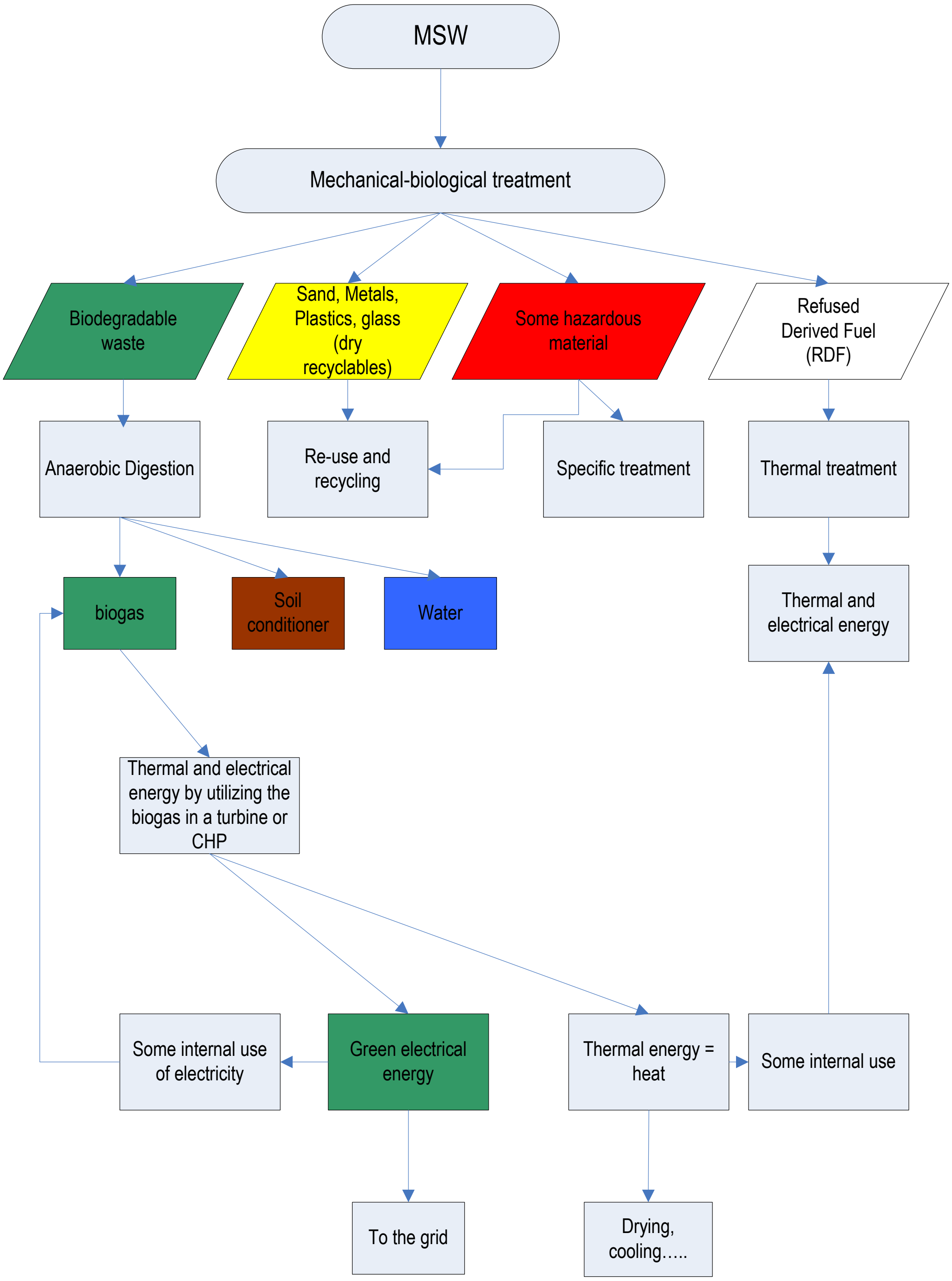
The disadvantages associated with this scenario may be summarized as follows:-

- Without the thermal treatment option this approach is only a partial solution, because the valuable RDF fraction has to be stored (limited to 3 years) or will end up in a landfill.
- The treatment capacity is very limited and restricted to MSW
- Regime experienced operators are required
- Limitation of the total amount of acceptable production of compost.

The RDF fraction is an excellent energy resource due to its high calorific value and to landfill this material is a waste of energy and landfill space. The storage of this product is possible, but limited to 3 years due to legal requirements.

An alternative option for the RDF would be the export to a thermal treatment facility abroad. However, the export of this product would necessitate the observance of certain criteria like constant chemical and physical properties to guarantee the consumer a constant quality of the refuse derived fuel. The market for this product is very limited. If we calculate the costs for the export, the costs for the disposal of the residues of the thermal process (e.g. bottom ash, fly ash), this solution would be highly questionable from an economical point of view and cannot be regarded as a sustainable waste management solution. In this case we also have to take into account the environmental impact by exporting the waste material over hundreds of miles for thermal treatment. The obligation of a country is to take the responsibility for the waste produced, its treatment and disposal with the least environmental impacts whilst respecting the proximity principle.

Scenario 2: Schematic description of the Sant Antnin facility including thermal treatment of RDF



Environmental Benefits

The benefits of this scenario are the following:

- Fulfillment of the first stage of the Landfill Directive in 2010
- Contribution to the recovery and recycling targets by mechanical separation
- Diversion of some hazardous waste from the landfill
- Production of biogas which is an alternative, renewable, “green” fuel and energy source
- This solution is a net energy producer (contribution to the renewable energy target)
- Saving of fossil fuels
- Increase of the production of renewable thermal and electrical energy
- Reduction of Green House Gases (Biogas is CO_2- neutral)
- Efficient treatment of biodegradable waste and RDF
- Flexible treatment solution
- Tailor-made preparation of different waste fractions for anaerobic digestion and thermal treatment
- Maximum reduction of material for landfill

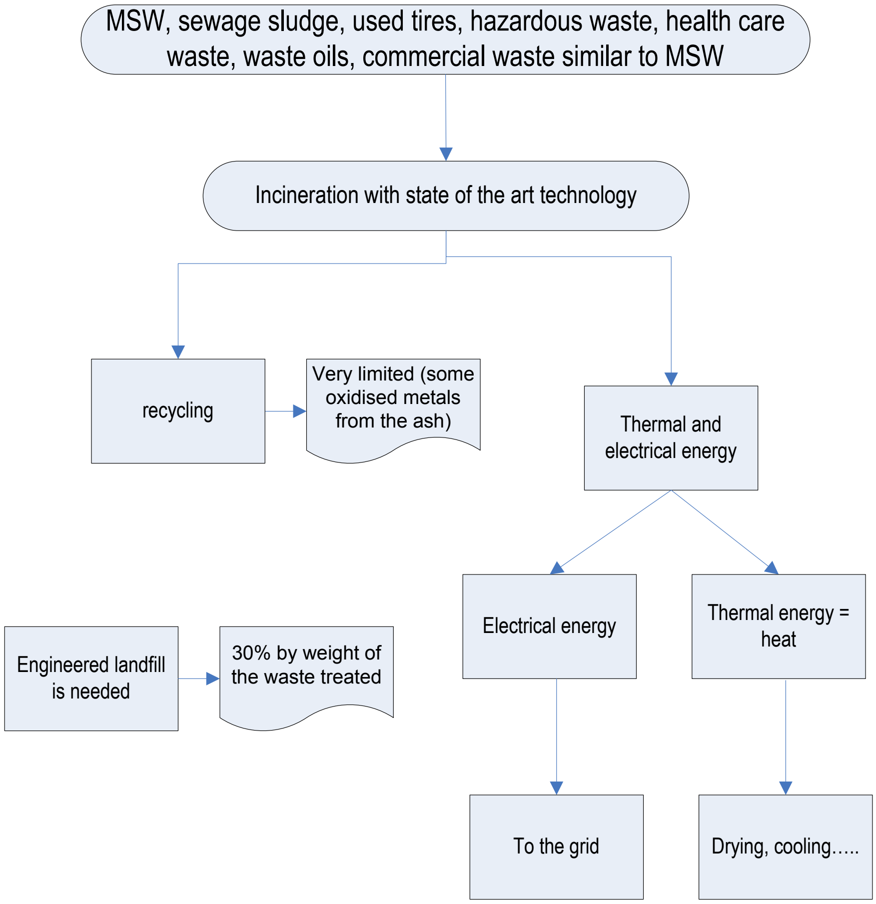
Disadvatages

This scenario would pose the following disadvantages:-

- The limited treatment capacity of the Sant Antnin facility restrictions to the amount of MSW that may be treated
- The siting of an additional thermal treatment facility for RDF may be contentious
- The utilization of the valuable excess heat of the thermal plant could be very difficult
- Regime experienced operators are required

We assume that the implementation of separation schemes, bring-in sites and civic amenity sites will be successful and therefore the amount of MSW to be treated at Sant Antnin will decrease steadily and therefore the output of RDF will decrease in a similar manner that would make a thermal treatment facility too small to operate there. The treatment of biodegradable waste (anaerobic digestion) and dry recyclables has to continue in order to guarantee the treatment capacity for biodegradable waste and dry recyclables. This will contribute to Malta’s renewable energy and recycling targets.

Scenario 3: Thermal treatment of all our waste streams with state of the art incineration technology



Environmental Benefits

The benefits associated with this scenario are the following:-

- Reduction of weight by 70%
- Reduction of volume by 90%
- Thermal destruction of organic pollutants
- Production and utilization of energy from waste in form of electricity and heat

Disadvantages

In contrast the perceived disadvantages are thought to be the following:-

- Poor public perception
- Plants tend to have large footprints
- Perceptions and benefits of the anti incineration lobby
- Engineered landfill is still required albeit for reduced volumes
- Flue gas cleaning is expensive due to high flue gas volumes
- Huge investment for incineration and landfill required
- Fixed waste management solution for up till 30 years
- Very limited material recycling possibilities; only some oxidized metals from the bottom ash (recycling of paper/cardboard and plastic is impossible)
- Experienced operators are required

Standard incineration plants are designed for a lifetime of 30 years and are most economic when operated as single large-scale plants (minimum capacity of 100,000 tons per year). The costs for a facility with a capacity of 100,000 tonnes per annum would be between 70 and 100 million Euros. Preferably these plants should be situated near to a “consumer” that utilizes the electricity and heat generated in an efficient way and to benefit from synergies. The location of a single incineration plant near a power station could have possible synergies which would be:

- the implementation of the flue gas treatment of the power station into the thermal treatment facility,
- provision of steam from the incineration process to the power station,
- sharing of the electricity distribution system and infrastructure
- sharing of the excess heat from the electricity generation for cooling applications or to produce water.

However the technical, economical and logistical problems must be explored further and weighed against having a stand alone plant.

In 2007 the improvement of the Sant Antnin plant will be completed and the advantages have been outlined in scenario one. The same treatment plant with a capacity of 170,000 tons MSW per annum would produce approximately 30,000t of RDF and a considerable amount of biodegradable waste for anaerobic digestion. The tailor-made utilization and exploitation of our waste as an energy resource is granted. The construction of an incineration plant with the capacity to treat all our waste would render the improvement of Sant Antnin and future developments in mechanical or thermal treatment solutions obsolete.

Directive 2001/77/EC clearly states that the incineration of non-separated municipal solid waste should not be promoted under a future support system for renewable energy sources.

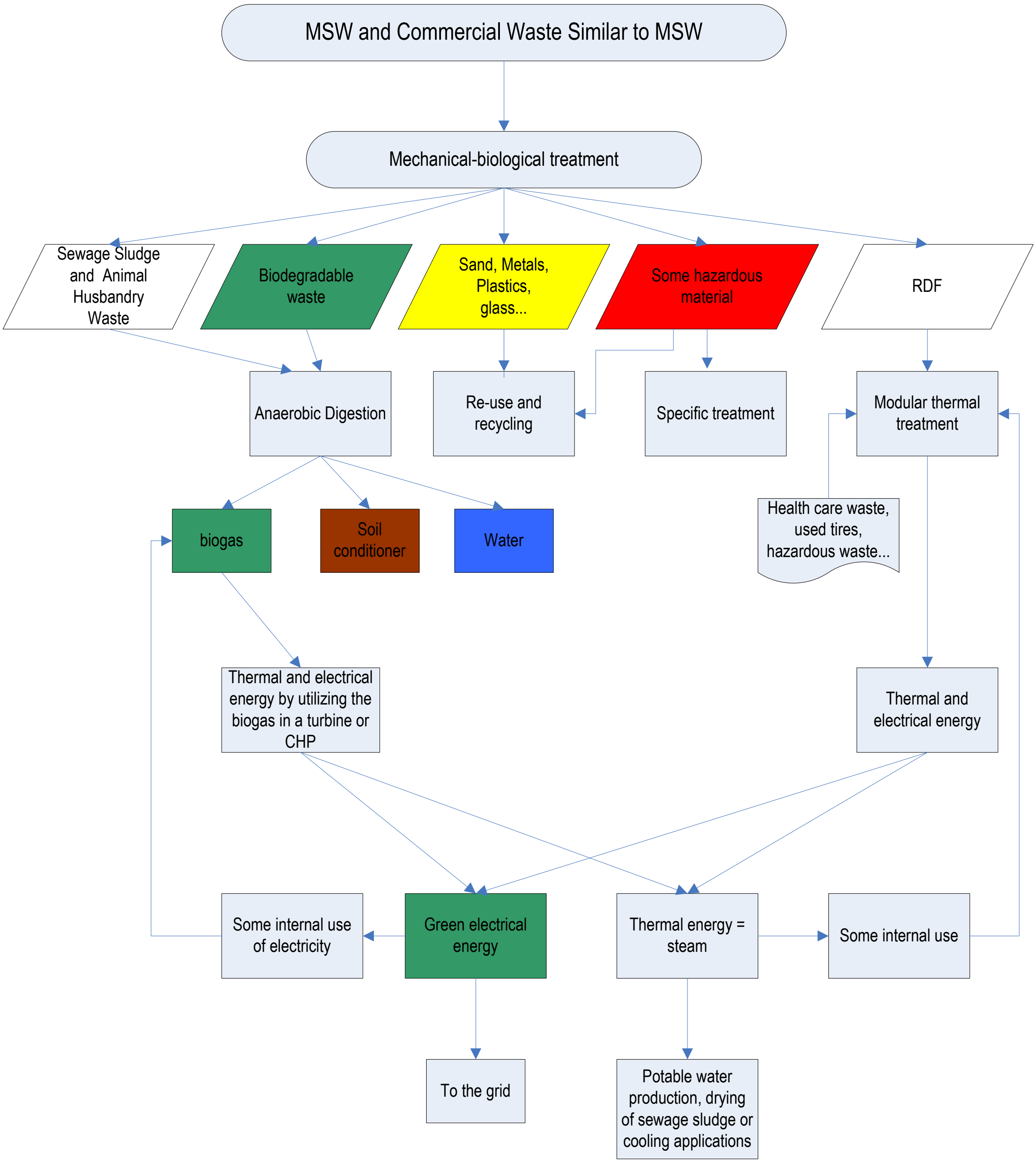
The combination of mechanical-biological treatment with standard incineration is possible, but expensive, because an economical incinerator capacity should be in the range of 100,000 ton per annum and in combination with a mechanical-biological treatment plant the amount of combustible material would be far below. Even the additional amount of sewage sludge, hazardous waste and healthcare waste would not be enough in order to grant an appropriate utilization rate.

Within 30 years the current scenario may be altered, be it through changes in socio-economical structure of Malta, the composition of waste generated, the decrease or increase of the amount of waste, the intensification of emission limits and last but not least the technical developments in the waste treatment sector.

There is no doubt that the thermal treatment of waste is a meaningful waste management option. However, the technical developments in the thermal waste treatment sector of the last 20 years showed that there is a large and exciting potential for alternative thermal treatment technologies (e.g. gasification, pyrolysis). The main advantage of pyrolysis and gasification is the potential for converting waste into a resource (e.g. alternative fuels) in an environmentally sustainable way including energy production.

In times of uncertainties as the oil market and oil prices become extremely volatile the developments of these “new” technologies is anticipated to proceed at a faster rate.

Scenario 4: The integrated waste management and treatment approach for Malta



Advantages

The main advantage associated with the scenarios are the following:-

- o Fulfillment of the Landfill Directive
- o Contribution to the recovery and recycling targets by mechanical separation
- o Production of biogas, and other valuable alternative “fuel” sources from waste
- o Energy recovery through thermal treatment and utilization of additional waste streams
- o This solution is a net energy producer
- o Saving of fossil fuels
- o Production of renewable thermal and electrical energy (renewable energy target)
- o Reduction of Green House Gases (Biogas is CO_2 neutral)
- o Efficient treatment of a wide range of different materials (MSW, commercial waste similar to MSW, animal husbandry waste, sewage sludge)
- o Relief of the sewage treatment plant due to diversion of animal husbandry waste from the sewer system
- o Modular expandable and flexible treatment solution
- o Taylor-made preparation of different waste fractions for anaerobic digestion and thermal treatment in one simple low-cost operation
- o Flexible and efficient waste management solution due to optimal use of the different waste components

Disadvantages

- o Heat applications other than water production are not always possible
- o Regime experienced operators are required
- o Objections to the Sant Antnin plant remain. Limit to compost production. Nimby objections
- o Low rate of volume reduction compared to incineration

Conclusion

Due to the absence of huge amounts of certain kinds of waste, standard incineration is probably the most expensive and most inflexible waste management solution for Malta. Initially this solution could be a possible way forward, but this path would definitely lock the possibilities to utilize new technical and sustainable developments in the field of waste management. The possibility of the exploitation of the valuable resources and different raw materials in our waste through advanced treatment technologies would not be possible and this would prevail for a number of years - at least 30. Why should Malta ignore the technical solutions of modern waste treatment and the possibilities of extracting the raw materials for renewable and alternative fuels from waste? The situation on the oil market is not predictable for the next 30 years and replacing part of the import of oil in the range of approximately 5% by using all the resources present in the waste is highly advisable.

The implementation of a thermal treatment facility in combination with mechanical – biological - treatment (MBT) is absolutely necessary in the near future. The RDF fraction out of the MBT process is definitely not a landfill fraction and should be used as a valuable source for energy, heat and alternative fuel production.

Proposal

The fact that Malta is a small island makes it rather difficult to advise a sustainable and economically feasible solution. For this reason a single large-scale waste treatment system like an incinerator with its disproportionate high investment costs and inflexibility cannot be recommended. Scenario 4 seems to be a practical, valuable and efficient approach with the opportunity to realize synergies in various ways and the thermal treatment of some hazardous waste streams could be also possible.

The improvement of the Sant Antnin facility should be finalized by 2007. The design capacity is limited but sufficient to fulfill the first step of the Landfill Directive in 2010 and could be adequate until 2013. The design of additional treatment solutions is therefore unavoidable and facilities should be operational at the latest by 2013, preferably in 2010. Due to the reason that incineration of untreated waste should not be promoted under a future support system for renewable energy sources the design of a second larger mechanical-biological treatment plant (including anaerobic digestion) would be the logical next step. The existing Sant Antnin plant would then also act as a backup system for the second MBT plant, which is absolutely necessary in case of maintenance works or technical problems in the second plant. The dependency on one treatment system could cause serious problems.

This new facility should have a treatment capacity of approximately 135,000 tons, with the potential for modular expansion also being recommended. It should also cater for the thermal treatment of the produced RDF and some other waste streams. The thermal facility, preferable a modular system, would produce a substantial amount of electricity and heat. The considerable excess heat should be utilized for the production of water, or the drying of sewage sludge or as energy source for cooling applications.

The utilization of heat to produce fresh water contribute towards sustainable development. A possibility is the combination of the thermal treatment process with a sea water distillation plant. This would be a combination of a steam generating plant fuelled by waste, a back pressure steam turbine – generator unit, and a thermal evaporator utilizing the exhaust steam. The heat energy utilised will lower the electrical energy consumption of the reverse osmosis plants.

The fact that transport of waste is unavoidable but contributes to pollution in a significant degree, it is highly advisable to implement a similar (except thermal treatment) and of course much smaller solution for Gozo. In fact Gozo could offer the possibility for a pilot scheme in this respect.

The combination of mechanical pretreatment, digestion of the biodegradable waste, thermal treatment of the high calorific value waste seems to be the right solution for sustainable development in Malta. Both methods (digestion and thermal treatment) are feedstock sensitive, but with accurate pretreatment the quality of the feedstock is predictable, an optimal energy output is achievable and the amounts of residues (vitrified slag, syngas, biogas, dry recyclables, soil conditioner) are minimal and can be used for further applications. The vitrified slag could be used in the construction industry (e.g. road construction material), the syngas/biogas as a fuel for a turbine or fuel cell to generate electricity and the heat as an energy resource for cooling systems or the production of water. The composted residues of the digester are a suitable soil conditioner and cover material for landfill. These examples demonstrate that waste can serve diversely as raw material with the aid of different standard technologies.

Overview of the Four Scenarios

	Efficient and flexible solution	Contribution to the recycling/recovery target and compliant with the Landfill Directive	Contribution to the renewable energy target	Landfill required
Scenario 1 (Sant Antnin)	Limited to MSW, biodegradable waste and dry recyclables	Yes (until 2010)	Yes	Yes, (due to the limited treatment capacity)
Scenario 2 (Sant Antnin plus thermal treatment of RDF)	Limited to MSW, biodegradable waste and dry recyclables	Yes (until 2010)	Yes	Yes, (due to the limited tr eatment capacity)
Scenario 3 (incineration of all waste streams)	No	Limited to some metals from the bottom ash	Not applicable	Yes (10% of the volume of the waste treated)
Scenario 4 (integrated waste management)	Yes	Yes	Yes	Yes (limited to some inert solids)

08. The Environmental Aspect

08.1 Introduction

The committee has considered information from two main sources, namely that provided as a result of a Request for Information (RFI) exercise as well as information obtained from other documentated sources. In the RFI, a number of technologies were presented that claim to convert waste to energy and these were incineration, anaerobic digestion, pyrolysis, gasification and conversion of waste to plasma; moreover, technologies were also described that do not involve a waste to energy system but simply a conversion of municipal solid waste (MSW) into a form or other of refuse-derived-fuel (RDF), which is a material that can be combusted more conveniently than raw waste in some dedicated plant to produce energy and other by-products.

08.2 Incineration and its impact on environment and health

8.2.1 Incineration

Incineration is the controlled combustion of waste in order to 'destroy' most of the mass thereby reducing the amount and volume of waste requiring landfilling and altering its chemical composition generally by transforming it into less hazardous material. In reality, the waste is *not* destroyed in the process but actually transformed from solid into a mixture of a gas, namely carbon dioxide (CO_2) and water. Incineration of MSW brings about a reduction in mass of about 70% but, more significantly, a reduction in volume of 90%.

Not all of the carbon dioxide emitted during incineration contributes to global warming but only that produced from the combustion of plastics, synthetic rubbers and oily residues (including petroleum-derived sludges); CO_2 derived from incineration of garden waste, food, paper, wood, sewage sludge and similar biomaterial-derived matter does not affect the global atmospheric carbon cycle.

Although incineration of most waste materials leads to detoxification of the waste, this is not true for certain types of substances in waste: thus, in the combustion chamber, compounds of lead, mercury and cadmium in the waste are transformed into vapours of the metals or the metal salts and such toxic vapours require absorption by the flue gas cleaning systems that constitute the most substantial part of a waste incineration system. Because incineration converts most toxic wastes into safe by-products, the technique can also be used for the management of industrial and hazardous waste, including clinical infectious matter, provided that the waste contains combustible material which is usually carbon-containing.

8.2.2 Environmental impacts from mass burn incineration

Impact on quality of air: flue gas emissions

Emissions from incineration of waste that are of major concern are total particulate matter or dust, acidic gases (HCl, HF and NO_x, SO_2), heavy metal compounds (especially mercury, lead and cadmium) and organic products of incomplete combustion (PIC's), especially polyaromatic hydrocarbons (PAH's), polychlorinated dibenzo-p-dioxins (PCDD's) and polychlorinated dibenzofurans (PCDF's). All of these compounds are harmful if inhaled or ingested and some are highly persistent in the environment and moreover can bioaccumulate and contaminate the food chain.

If uncontrolled, heavy metals exert a range of toxic health effects including carcinogenic, neurological, hepatic, renal and hematopoietic: cadmium, mercury and lead are particularly problematic because of their high abundance in MSW, their greater toxicity and also the volatility of their compounds and hence their mobility in the environment. PCDD's and PCDF's constitute a group of 210 different compounds of widely varying toxicities which have been demonstrated to occur widely in the environment ranging from soils, chemical formulations such as herbicides, landfill sites and burnt forest debris.

These compounds are also found in ash, chimney effluents and process fluids from the combustion of MSW, industrial wastes but also coal and wood (The compounds are also found in fireworks smoke). 'Dioxins' and 'furans' are highly toxic at very low levels of exposure and are believed to have a potential to produce a spectrum of health effects including cancer to humans21. The primary route for human exposure to toxicants released by incineration is the food chain; the risk to health is enhanced since the chemicals are present in airborne fine dusts which, being readily adsorbed onto the surface of other particles, are more likely to be ingested.

Following introduction, in the nineties, of EC legislation on emissions from incinerators throughout Europe, control of environmental pollution has become a major part of the process, constituting the principal item of cost, technological sophistication and space requirement of the plant. Incinerators are now equipped with afterburners, cyclone filters, scrubbers, fabric filters and electrostatic precipitators and these air pollution control devices acting in tandem comprise a significant part of a modern incineration plant. While it is generally accepted that these devices reduce to acceptable levels emissions from the incinerator chimney, they also generate solid and liquid wastes which need to be managed along with the ashes from incineration and these "wastes from waste" are discussed briefly below.

Impact on land and freshwaters from contaminated ash and wastewaters

Bottom ash from an incinerator constitutes about 9% by volume (and 27% by mass) of the original municipal waste: it represents the solid residues after removal of the ferrous metal fraction; flyash constitutes about 1% by volume. Bottom ash, which has the consistency of sandy gravel, is composed mainly of mineral oxides. Its heavy metal content is generally lower than 1.5% by mass but is highly variable and depends on the composition of the original waste: generally, the content of heavy metals in bottom ash is less than that in flyash. Moreover, flyash is also contaminated with PIC's.

In Europe, bottom ash is recycled as aggregate for use in construction and roadbuilding and is also used as a landfill cover. Flyash, on the other hand has no recycling properties and its contamination with heavy metals and PIC's qualify it as a hazardous waste requiring special landfilling conditions. These are aimed at preventing contamination of ground water from any leachate from the ash. Treatment methods for flyash exist or are currently under investigation which attempt to stabilise the ash by various techniques (e.g. solidification, vitrification and chemical treatment). Such treatments obviously increase the cost of disposal.

Water pollution from incinerators is not regarded as an important problem because of the limited amount of wastewater generated in wet scrubbers and other pollution prevention devices in the plant. The rate of wastewater generation is about 2.5 m^3 per tonne of MSW incinerated. The main pollutants in the wastewater are heavy metals and these can be removed by precipitation with lime and chemical additives. Filtration of the water removes suspended fines which are contaminated with heavy metals and PIC's.

Other impacts

The visual impact of an incineration plant, as well as that of its stack, on the surrounding areas are not negligible. There is also an increased traffic impact arising from the transport of waste to the incinerator and ash away from the incinerator: it is likely that this traffic would have an adverse affect on the local air quality and on the amenity value of the roads leading to the incinerator.

Another perceived impact would be loss of value of adjacent property since such a facility is likely to be regarded as a locally unacceptable land use (LULU).

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[21] The evidence is largely based on animal testing and there is no clear and conclusive link between exposure to dioxins and furans and long-term adverse health effects in humans. Despite this, however, the perceived risk remains of high concern to the public (e.g. see *Risk assessment of dioxin releases from municipal waste incineration processes,* Env. Agency (HMIP), Dept of Environment, HMSO, London, 1996)

8.2.3 Risk to human health from incineration

The major issue regarding health impacts from incineration pertains to air pollution. As mentioned previously, incinerators incorporate robust flue gas treatment systems that are designed to ensure emissions of harmful substances are kept to acceptable levels[22]. An acceptable level of emission of a toxicant is one that does not affect significantly the health of a community that is exposed to the emissions. Emissions from incinerator plants may be monitored continuously using tamper-proof instrumentation and the information relayed in real time and directly to the relevant environmental agency: this is to ensure that operational controls are in compliance with safety standards at all times to the satisfaction of both the environmental agency and the general public.

Can the technology involved in pollution abatement in incinerators truly prevent contamination of the environment that would otherwise lead to adverse health effects? Informed expert opinions from several quarters agree that this is possible. We cite from a report to the UK Government by the Royal Commission on Environmental Pollution[23] published in 1993 which states that waste incinerators which meet present-day standards for emissions are an environmentally acceptable method of dealing with wastes which cannot be eliminated at source or recycled. In the case of MSW, the Commission concludes that incineration with energy recovery, followed by landfilling of the solid residues, was likely to prove to be the best practicable environmental option. Shortly after publication of this report (in 1994), the US Environmental Protection Agency published its work on the environmental occurrence of dioxins and furans and the relation to incineration. In reaction to this report, the Royal Commission issued the following statement[24] on 17 January 1995:

"The Commission made a detailed study of waste incineration in its 17th Report, published in May 1993. Among the factors considered were emissions of dioxins. The Commission has now reviewed its original conclusions in the light of two draft reports on dioxins published last year (1994) by the US Environmental Protection Agency. The Secretary to the Commission has confirmed however in a letter to the Department of the Environment that nothing has emerged which would lead the Commission to alter the views expressed in its 17th Report."

This Committee has no reason to doubt the conclusion of this and other similar reputable expert opinions, despite contrary opinions expressed by certain environmental groups.

08.3 Environmental impacts from pyrolysis and gasification of waste

A wide variety of pyrolysis and gasification technologies exist or are currently being investigated. Some modern systems even utilise hybrid combinations involving both a pyrolysis stage and gasification. Many of the technologies are still at the pilot-scale stage while others are at the commercial stage. Most represent quite recent developments in the field of thermal processing of wastes.

In pyrolysis, no oxygen is introduced as the waste is heated while in gasification, the amount of oxygen in contact with the waste is restricted so that it is sufficient to convert the carbon to carbon monoxide: in both processes, the chemical conversions are carried out under so-called 'reducing conditions'. In incineration systems, the conditions are highly oxygenated and this technology works under 'oxidising conditions'. Under reducing conditions, the transformation of gaseous pyrolysis products into dioxins and furans as occur in the cooler regions of incinerator plants (e.g. heat exchangers) is expected to be disfavoured because formation of these products requires oxidising conditions. It is therefore expected that the processes involved in pyrolysis/gasification would be cleaner: however, if these technologies can be compared to those for "starved-air combustors" then,

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[22] For dioxins, incinerators have to comply with the standard of 1 ng TEQ/Nm^3 with a guide value of 0.1 ngTEQ/Nm^3; compare this standard with actual measured values for Canadian and European incinerators using older technologies ranging between 50 - 1800 ng TEQ/Nm^3. (Ref: Hester and Harrison (ed). *Waste incineration and the environment,* Royal Society of Chemistry, 1994, pp.77.)

[23] Royal Commission on Environmental Pollution, 1993, 17th Report, Incineration of waste, HMSO, London.

[24] The full text is downloadable from the following Internet site: http://www.rcep.org.uk/news/95-1.htm

emissions from such systems are not expected to be devoid of products of incomplete combustion[25] and would likely require substantial gas cleaning technology to produce safe emissions.

It is reported that certain pyrolysis and gasification systems produce a granulate instead of an ash which can be more easily utilised and is a safer product. The ash from the electrostatic precipitators would be expected to be similar to that from similar systems in incinerators. Wastewater generated in pyrolysis processes is usually highly contaminated by dissolved and suspended organic substances although such wastewater is treated before disposal.

One cannot reasonably expect to find documented empirical evidence regarding specific environmental impacts from pyrolysis and gasification plants as have featured in connection with older generation incinerators: pyrolysis and gasification plants are relatively new technologies and there are not enough of them that have been operating for a sufficiently long period of time.

08.4 Plasma converter system for wastes

The ultra high temperatures generated by plasma torches have led this technology to be applied in the processing of hazardous wastes where these materials are converted into a gaseous product and a low volume non-leachable vitreous slag safe for landfilling. Plasma furnaces also operate under reducing conditions as for pyrolysis or gasification and generate temperatures that affect virtually complete molecular dissociation of the waste compounds, including dioxins and furans and other difficult wastes (e.g. asbestos). The 'synthesis gas' (syn-gas) produced, consisting mainly of carbon monoxide, hydrogen, nitrogen and some hydrocarbons with minor quantities of CO_2 and oxygen can be used for generation of electricity.

This technology, as applied to MSW, is even newer than conventional pyrolysis or gasification systems and the same or similar concerns as above (see Section 7.3) can be made in relation to any environmental impacts as this novel technology may present. The significant electrical power which would need to be dedicated to the plasma torch is claimed to be totally recoverable from the electricity generated from combustion in gas engines of the syn-gas with an excess being left over to be sold to the national grid[26].

08.5 Anaerobic digestion and its environmental impact

Anaerobic digestion is the microbiological degradation of organic material in the absence of oxygen. This results in the production of 'biogas' or 'landfill gas', a mixture containing approximately 60% methane and 40% carbon dioxide. Anaerobic digestion can be used to produce energy from waste streams of natural materials or to lower the pollution potential of a waste stream. Anaerobic digestion has been used to treat sewage sludge and agricultural wastes for many years; its application to MSW and industrial wastes is a more recent development[27]. The process takes place in an enclosed, closely controlled reactor. Factors which require control are pH of waste, nutrient content and the carbon:nitrogen (C:N) ratio of the waste feed stock. High C:N ratios as are associated with MSW may lead to lower methane production: co-digestion with sewage sludge would be one method of decreasing this ratio since this sludge is rich in protein (high in N content). The solid residue from anaerobic digestion can be matured into a compost product. Mixed MSW waste would require sorting to remove the non-digestible fraction such as metals and plastics so that the plant would require a materials recovery facility as a front end component.

A main concern regarding potential environmental impacts from an anaerobic digestion plant would relate to fugitive odours from the fermenting or composting systems resulting from operational breakdown of biofiltration systems when these are adopted for odour control. Non-biological systems

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[25] See for example, AP-42, Chapter 2, Table 2.1-9, US-EPA, where emission factors for priority air pollutants are similar to those for mass burn incinerators. Internet site : http://www.epa.gov/ttnchie1/ap42/ch02/final/c02s01.pdf

[26] See, for example, the report title *The commercial viability of plasma arc technology, A white paper,* (undated) prepared by the Solena Group (USA); Internet site accessed on 6th April 2005: www.solenagroup.com/html/images/plasma.pdf.

[27] The Valorga (Amiens, France) anaerobic digestion plant was built in 1988 to treat over 100 000 t/y of mixed MSW and 5000 t/y of industrial waste and produces 131 m^3 of gas per tonne of sorted waste.

such as regenerative thermal oxidisers (RTOs) pose no similar concerns and also avoid issues pertaining to atmospheric pollution by bio-aerosols as may be associated with biofilters.

A digestor facility would be expected to use the gas produced on site as fuel to generate electricity: flue gases from the combustion process will affect the air quality although it has to be noted that insofar as global warming potential is concerned, the CO_2 emitted is neutral. Also, the gas burns much more cleanly than liquid or solid fuels and is not contaminated with heavy metals.

As for any other waste treatment facility, transport of waste towards the plant and export of compost and other products from the plant would also affect negatively the quality of the air from vehicular emissions. Also, as for other waste treatment systems, such plants constitute a locally unacceptable land use and are generally regarded by the public as bad neighbours.

08.6 Summary of environmental impacts

The following table summarizes the main environmental impacts from the waste-to-energy processes described in this section.

Process	**Impact on air quality**	**Impact on land and water**	**Risk to health**	**Other impacts**
Incineration	Emissions are reduced to acceptable levels by proper abatement technology	Flyash is a hazardous waste and needs proper landfilling; bottom ash has re-use value; water pollution not an issue	Not significant due to abatement technology but negative public perception lingers on.	Significant visual impact; loss of value of adjacent property. Unless mitigation measures are not put up in place
Pyrolysis and gasification	Emissions are reduced to acceptable levels by proper abatement technology	Flyash is hazardous and needs proper landfilling; bottom ash is re-useable; wastewater may need treatment before disposal.	Not significant due to abatement technologies; negative public perception.	Significant visual impact; loss of value of adjacent property. Unless mitigation measures are not put up in place
Plasma torch	Emissions are reduced to acceptable levels by proper abatement technology	Vitreous slag safe for landfill; water pollution not an issue	Not significant in view of abatement technology.	(Insufficient information)
Anaerobic digestion-composting plant	Emissions are reduced to acceptable levels by proper abatement technology	Compost is produced which has a re-use value; water pollution not an issue.	Not significant due to abatement technologies.	Significant visual impact; loss of value of adjacent property. Unless mitigation measures are not put up in place

09. Financing Mechanisms

The Solid Waste Management Strategy for the Maltese Islands published in 2001, represented Government's policy direction statement on waste management. In this document, the importance of establishing a sustainable and cost effective waste management strategy was highlighted. In the 2001 Strategy, Government had already indicated its intentions for the introduction of waste to energy technologies by the year 2013. In January of 2005, Government appointed two bodies namely the Waste Management Strategy Team, tasked with the updating of the 2001 Strategy and a Waste-to-Energy Working Group, tasked with establishing the best technology/ies that could recover energy from our waste fractions.

Waste to Energy plants involve an extensive amount of capital investment. In order to minimise this extensive investment without immediate recourse to the public purse, experience from foreign jurisdictions has shown that Government most often opts for private sector involvement within the waste management sector. Private sector involvement also contributes towards:

- achieving a sustainable and cost effective strategy;
- benefiting from the experience provided by the private sector particularly in those projects where no experience has been gained to date; and
- waste related projects usually require an extensive amount of capital investment that may not be affordable to Government.

09.1 Defining Public Private Partnerships (PPPs)

Although to date there is no agreed general definition of what a Public Private Partnership (PPP) is, the most agreed definition is:

> *'a partnership between the public sector and the private sector for the purpose of delivering a project or a service traditionally provided by the public sector. Public Private Partnerships come in a variety of forms, but at the heart of every successful project is the concept that better value for money may be achieved through the exploitation of private sector competencies and the allocation of risk to the party best able to manage it[28].'*

PPPs recognise that there are some activities that the public sector does best and other activities where the private sector has more to offer. Only by allowing each sector to focus upon what it does best can Government provide the quality services that the public wants and expects. The overall aim of PPPs is therefore to structure the relationship between the public and private sectors in such a way that the activities and risks associated with the specification, delivery and regulation of pubic services are allocated to the party best able to manage them.

The precise roles and responsibilities of the public and private sectors in any PPP will depend upon the contractual terms agreed and will vary from project to project. The reasons for establishing such partnerships vary but generally involve the financing, design, construction, operation and maintenance of public infrastructure and services.

While in some projects, the private sector partner will have significant involvement in all aspects of service delivery, in others, it will only have a minor role. It is only the overall roles and responsibilities of Government that do not change. In all cases, Government remains responsible and accountable for delivering services and projects in a manner that protects and furthers the public interest. Guaranteeing benefit from PPP requires recognition of the relative strengths and weaknesses of each type of structure and the aims and objectives of each party.

[28] A Policy Framework for PPP's, Department of the Environment and Local Government, Ireland.

The success of a PPP depends on a number of criteria. In a PPP project:

- public and private sectors work together on the basis of clear contractual agreements;
- all parties must recognize and understand their objectives;
- the division of responsibilities, costs and risks is agreed by contract;
- both public-interest and commercial goals are served;
- both parties expect, through collaboration and the input of each party's specific expertise, to achieve a better result for the same cost (or the same result for less cost); and
- each party retains its own identity and responsibility and trust must be established between all parties.

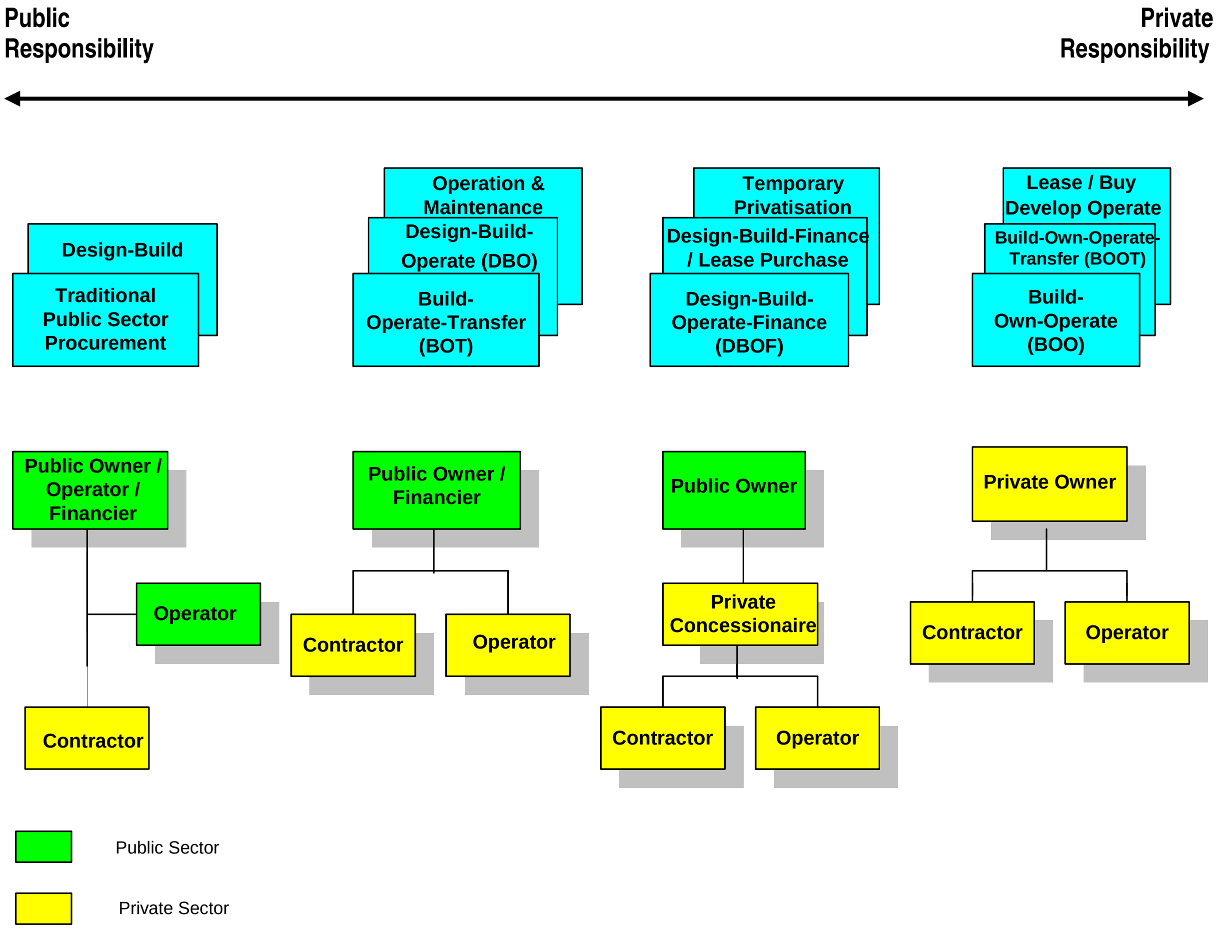
09.2 PPP Models

Different forms of PPP approaches are in existence and these vary in terms of how risks and responsibilities are allocated. They also vary in complexity and the degree of expertise required to successfully negotiate the required contracts. As depicted in Figure 1, PPP approaches are arrayed across a spectrum. At one end, the public sector retains all responsibility for financing, constructing, operating and maintaining assets, together with the responsibility for assuming all associated risks. At the other end, the private sector assumes all of these responsibilities. The vast majority of PPP approaches fall in the middle of the spectrum, with risks and responsibilities shared between the public sector and its private partners according to their strengths and weaknesses.

The main goals of these innovative project delivery methods are to produce projects that have better quality of longer life cycles, bring cost-savings to the client, transfer risks to the organisation best able to manage risks, include integrated processes and complete projects faster than traditional methods. Changing from one project delivery method to another usually takes time, experience and new approaches. A proper mix of models is probably a wise decision because it would not only allow faster completion of projects but also would keep the private sector industry balanced and competitive.

Each of the models, their applicability, advantages and disadvantages are discussed in greater detail in Appendix A.

Figure 1: Project Procurement Options



09.3 Private Finance Initiatives (PFIs)

Public Private Partnerships is the umbrella name given to a range of initiatives which involve the private sector in the operation of public services. The Private Finance Initiative (PFI) is the most frequently used initiative. The key difference between PFI and conventional ways of providing public services is that the public does not own the asset. PFI provides a way of funding major capital investments, without immediate recourse to the public purse. A typical PFI project will be owned by a company set up especially to run the scheme. These companies are usually a private consortium including a construction company, a bank and a facilities management company. Under such contracts the private sector typically designs, builds, finances and operates the assets required to provide the service contracted for and in return is paid on the basis of the service provided.

The PFI was introduced in 1992 in the UK by the Thatcher government and was developed for several purposes:

- to build new infrastructure in the public sector;
- cut back on government borrowing;
- increase the involvement of the private sector in the provision of public services; and
- as a tool to restructure the National Health Service (NHS) service delivery.

Under PFI, the private sector pays to replace public assets such as a new hospital, and in return the government or local authority leases the asset back by paying for services over the life of the contract. Instead of borrowing money to fund capital projects, the public sector makes a monthly payment to the private company to cover the cost of designing, financing, building, operating, and maintaining the facility.

The first PFI schemes were in transportation systems, roads and contracting out small services such as eye tests and dentistry, but finally PFI expanded to core services in the NHS, information technology, property, education, waste management, prisons, public housing and police services29. For example, with information technology services, all the necessary hardware and software is supplied, developed, operated and maintained by the private sector.

The public sector as part of the contract specifies the outputs required and pays for these outputs usually on the basis of volume subject to agreed quality criteria. Typically no payments are made by the public sector until the systems supplying the services are operating satisfactorily. Similarly with roads, the private sector designs, build, finance, and operate the road construction and maintenance of the road over the life of the contract (perhaps 30 years), and the public sector pays the operator a toll for each vehicle kilometre travelled along the road. Under such arrangements, all risks associated with design, development, construction, and maintenance necessary to provide the services contracted are borne by the private sector as they only receive payment when the service is in place.

09.4 PPP in Foreign Jurisdictions

Waste generation in the last decade has increased considerably throughout Europe. It is estimated that in the European Union alone 1.3 billion tonnes of waste are disposed of, out of which around 40 million tonnes are hazardous. Members of the European Union have introduced and are implementing waste management strategies to be able to achieve the objectives set by the same EU in order to have a better environment in the future.

These initiatives should be carried out in such a way that should not be of a burden to the public finances but should be a new incentive for both the public and private sector. In the waste management sector such initiatives are financed through a PPP, although there is no standard model of which to apply.

The Working Group has analysed 4 case studies in this sector. These are:

- Northumberland, United Kingdom;
- Dublin, Ireland;
- Kirklees, United Kingdom; and
- Denmark.

9.4.1 Northumberland, United Kingdom

Northumberland is England's most northerly county, covering some 5,000 square kilometres between the Scottish Border in the north and Tyneside and County Durham in the south.

Recently, Municipal Solid Waste (MSW) risings have been increased by about 5% per annum. This further enhances the fact that statutory targets need to be achieved as well as the Council would have to face unmanageable cost increases if the required solutions are not delivered on time.

The United Kingdom has established national targets to recycle and recover value from municipal solid waste (MSW). These are:

- 25% recycling/composting and 40% recovery by 2005;
- 30% recycling/composting and 45% recovery by 2010; and

[29] Canadian National Unions, 1999; BMJ July 6, 1996.

- 33% recycling/composting and 67% recovery by 2015.

In order to address Waste Management, the County of Northumberland has issued a PFI contract for the provision of waste services proposed against output specifications defined by the Council.

The proposed PFI is to address the objectives of the Waste Strategy set by the Council. The main objective of this contract is to achieve the provision of integrated facilities and services that manage waste in an environmentally and economically sustainable manner. This should contribute towards:

- minimisation of waste arisings;
- achievement of recycling and composting rates;
- diversion of waste from landfill; and
- achievement of biodegradable landfill diversion targets.

Moreover, the PFI Contract shall contribute in providing an improved level of service to the public as well as will provide the Council with a degree of certainty of future costs.

9.4.2 Dublin Waste to Energy Project

The City Council of Dublin which is acting on behalf of all four Dublin Local Authorities has launched the 'Dublin Waste to Energy' Project'. This project is to provide and operate a thermal treatment plant to treat household and commercial waste that cannot be reused, recycled or land filled in the region of Dublin. This thermal plant will be capable of treating up to 500,000 tonnes of waste per annum.

The decision of setting up of a thermal plant was taken in the light of an integrated waste management strategy. The objective of an integrated waste management strategy is to minimise the amount of waste going to the landfill. This objective is achieved by:

- reducing the amount of waste generated ;
- recycling as much waste as possible;
- recovering energy from waste; and
- landfilling residual waste.

Thermal Plant

Thermal Treatment is a process by which heat is applied to waste in order to reduce its bulk, prior to final disposal. The process may or may not involve energy recovery. Thermal treatment can involve a number of processes the most common of which is referred to as incineration.

Energy recovery from thermal waste treatment plants is possible due to the fact that waste itself contains large amount of thermal energy. This energy must be converted in a useable form and this may happen in one of the following:

- heat recovery boiler in waste combustion plant;
- combustion of synthesis gas in heat recovery boiler; and
- combustion of synthesis gas in gas engine.

The first two methods produce high pressure steam which is used practically all fuel fired electricity generating station in turn producing electrical power. Electricity is the most valuable form of energy the plant can produce as it may be used in so many different ways. It also comes with the great advantage of being easy to supply to customers via a supply network. This means that for every one tonne of municipal solid waste thus could yield up to 500kWh of electricity.

Financing Waste to Energy Project in Dublin

A Consortium has been appointed by the Dublin Corporation (acting on behalf of the local authorities). This Consortium made up of leading Irish engineering and environmental consultants is to plan the development of the plant on behalf of the local authorities.

The Consortium was set up with the intention of:

- providing information to the public;
- identifying possible environmental impacts;
- consulting the public about ways to minimise impacts;
- facilitating the tendering process;
- ensuring the best available technology is used; and
- facilitating the establishment of a Public Private Partnership to design, build, operate and finance the plant.

Public Private Partnership

This is the first major waste project to be implemented under the Irish PPP programme. This plant is financed through a concession type of contract through a DBOF approach. This partnership which has been set up between Dublin Corporation representing the public and a private company, where both parties share cost, expertise, technology and responsibility for developing the plant. This ensures that the public gets the best service providing value for money. The company can then charge for the use of the facility which can revert to the local authority after a 20-year period.

In recent years, the PPP approach for infrastructural projects and for the procurement of assets and services has become a key part of the Irish Government policy. The Strategy adopted by the Irish Government to reduce reliance on land filling and to construct and operate other types of waste management facilities such as energy from waste plants has resulted in the emergence of PPP procurement. These plants require substantial investment and advanced technical capability. Most of these plants are operated under a DBOF partnership approach and at present, procurement processes have started for new facilities at Ringsend in Dublin for energy to waste plant.

9.4.3 Kirklees, Great Britain

In order to meet the arising waste sector requirements, the private sector has developed a significant ability to meet such requirements. At the moment in Great Britain, there are about eight energy from waste (EfW) plants in operation, and a number of these have been procured under PPP contracts. Approximately there are eight sector players in the waste industry, out of which five have the necessary expertise and track record to bid for large projects.

A waste management contract between the public sector Kirklees Council and the private company SITA is a useful example of a successful PPP project. Situated in the West Yorkshire, Kirklees is responsible for the local administration of a population of 390,000 with its principal town being Huddersfield. The council is responsible for about 250,000 tonnes of municipal solid waste (MSW) that arises annually in this area.

During 1996, the Council invited tenders using the EU Services Directive and Restricted Procedure for a 25 year DBOF contract. The main outputs to be achieved were:

- provision of facilities for the receipt of all collected solid waste;
- provision of new and upgraded civic amenity sites;
- diversion of at least 60% of waste away from landfill; and
- transportation and disposal of all residual materials.

The tenders did not stipulate how the diversion of at least 60% of waste away from landfill was to be achieved. In 1998, the agreed contract stated that a new infrastructure had to be constructed as follows:

- 15,000 tonnes per annum MRF to handle kerbside collected recyclables - now operational;

- o transfer station with capacity of 100,000 tonnes per annum of household waste - now operational;
- o energy from waste plant with capacity of 135,000 tonnes per annum to receive household and commercial waste - construction completed, commissioning underway;
- o 2 composting facilities for civic amenity green waste - now completed; and
- o improvements to existing civic amenity sites - now completed.

The Waste to Energy plant was constructed at Huddersfield which is the principal town of Kirklees. The current waste disposal strategy was developed in the mid-1990s with the aim to maximise the recovery of value from waste. The strategy developed included recycling, composting, waste to energy and as a last resort landfill. In order to divert as much waste as possible from the landfill, the old incinerator at Huddersfield has been completely refurbished into a new waste to energy plant. The plant has been designed to process 136,000 tonnes per annum.

This plant was procured as part of the 25 year integrated waste disposal DBOF contract with SITA Kirklees Ltd. and has been designed according to the most stringent European standards. The plant generates 10 megawatts supplying 10,000 homes is fed in the national grid. At the moment a proposal to use surplus heat to supply energy for district heating scheme is being evaluated.

9.4.4 Denmark

Denmark has been actively working to provide solutions within the waste sector dealing with solid and hazardous waste. These solutions are mainly based on extensive cooperation between authorities, research institutes, private companies and public enterprises.

As in other countries, Denmark based its waste policy and strategy on the internationally recognised waste hierarchy. These are prioritised as follows:

- o setting up of initiatives to prevent waste generation;
- o maximising recycling and material recovery;
- o optimising the recovery of the energy contents in waste;
- o minimising the use of landfilling.

At the moment 58% [30]of the waste being produced in Denmark is used to produce energy which is one of the highest contributions rate in Europe.

Public / Private Partnerships in Denmark

The setting up of PPP's within the solid waste management sector is often recommended since this sector involves high costs. In this respect PPP's constitute a central model in which the combined efforts of the public and private sector produce a dynamic element in the implementation of new solid waste management systems.

Common PPP models used in Denmark within this sector are the Design, Build, Operate and Finance (DBOF) model, Concessions and Private Finance Initiatives (PFI). The decision of which of the aforementioned to apply often depends on the particular project being established.

09.5 Summary of Findings

Different types of PPP contracts are already being implemented in Europe. International experience has shown that if designed appropriately, PPPs can generate substantial benefits for consumers and taxpayers. The scope of potential benefit will however depend on the type of project being undertaken and the exact terms of the contract governing the PPP. Used in appropriate circumstances and developed in an effective manner that reflects the discussion, PPPs have the potential to deliver important benefits.

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[30] SITA Energy from Waste Position Paper 2004

BOT contracts are more suitable where the private sector will receive user fees paid by the public sector, but the public sector will finance the project and accept the risk associated with demand. In case of major road projects, **DBOF** contracts are likely to be more suitable where the private sector contractor will accept some of the risk associated with traffic demand, but user tolls are not applied. A number of major road projects have been undertaken in the UK, Finland, Scotland, Portugal and Spain on this basis and the private sector contractors are paid on the basis of tolls. Minor projects are more suited to traditional **DB** contracts and are not likely to be suitable for other forms of PPP unless bundled together into a larger contract with a significant operating element.

Water supply and waste water facilities are likely to be very suited to **BOT** and **DBOF** contracts. They may also be suited to Concession contracts where there is an opportunity to introduce user charging. Such facilities are considered to be less suited to traditional procurement **DB** contracts as the public sector would retain the risks associated with operating increasingly complex treatment processes without having had a role in the design of those processes.

From the analysis of foreign jurisdictions on may note that the main models used within the waste management sector are as follows:

- o Design, Build, Operate and Finance (DBOF) model;
- o Concessions; and
- o Private Finance Initiatives (PFI).

9.5.1 DBOF, Concession and PFI

Table 1 compares the DBOF, Concession and PFI models. This table outlines the definition of the aforementioned models as well as the pros and cons involved of each of the models.

Table 1 - Comparison between the Three Models DBOF, Concession and PFI.

DBOF	Concession	PFI
Definition		
o Contractual relationship between public sector and private contractor for the DBOF of **an already existing public facility/ infrastructure,** o Responsibilities for designing, building, financing and operating risk are bundled together and transferred to private sector partners. o The facility is owned by the private sector for the contract period. o The contractor recovers its costs out of payments from the public sector.	o Similar to DBOF arrangements, o Can be awarded for the **construction of a new asset, upgrading or expansion of an existing facility.** o Ownership of assets both existing and new remains with the public sector. o Costs are recovered either through direct user charges or through a mixture of user charging and public subvention.	o Asset is not owned by the public sector. o PFI projects usually set up a company especially to run the scheme o Costs are recovered through the services provided. o Outputs specified by the public sector and usually pays for these outputs on the volume subject to agreed quality criteria. o Risk is borne by the private sector since it only receive payments when the service is in place.
Advantages		
Attracts investment from the private sector	Same advantages of DBOF	PFI provides public services without immediate recourse to the public purse
Financing risks lie within the private partner	Additional increased level of demand risk transfer	Risk lies within the private partner
Increased flexibility for procurement	Encourages third party revenue	PFI manages to cut back on government spending
Time reduction in project implementation.		No payments are made by the public sector until the systems supplying are operating satisfactorily

Disadvantages		
Future facility upgrades not included in the contract with the private partner may be difficult to incorporate at a later date	Same disadvantage of DBOF	Asset is not owned by the public sector
Expense involved in alteration of existing contract with the private partner	May not be politically acceptable	
Perceived loss of control	Requires effective management of alternatives / substitutes e.g. alternative transport routes or alternative waste disposal options	
Contacts are more complex and tendering process can take very long		
Contacts are more complex and tendering process can take very long		
A change management system together with contract management and performance monitoring systems are required		

9.5.2 Conclusion

After analysing foreign jurisdictions, one may note that the main focus on the three aforementioned models is on private sector involvement in the waste to energy sector. This mainly arises from the fact that the solid waste management sector requires a high degree of investment which may not be always affordable to Government. Moreover, the private sector may also contribute from the expertise acquired in the sector.

One of the main differences between these three models is the ownership of the asset. When using the DBOF and Concession approaches, the assets are owned by the private sector for the duration of the contract after which ownership is reverted back to the public sector. In the case of PFIs ownership of the asset remains of the private sector.

Another main difference between DBOF and Concessions is that in the case of DBOF it can only be awarded in the case of an existing public infrastructure, whereas in the case of a concession it may be the construction of a new facility, upgrading of a facility or an expansion of infrastructure.

09.6 The Involvement of the Private Sector in the Maltese Scenario

Public Private Partnerships are a relatively new concept to the Maltese scenarios although the principle has been recognised and has become firmly entrenched in being an option that is always considered in the implementation of certain types of projects.

Public procurement systems have, in the past, strongly relied on subcontracting wherein a particular set of services of goods are procured from a third party in a client-supplier relationship. However, following Budget 2003, the Minister of Finance had announced that Government would be seeking to establish public private partnerships for certain services currently offered by Government. The scope was to attach the workforce that was employed by Government to a strategic partner who who utilise such resources in order to deliver a set of specific deliverables.

In fact a typical example of this model was the Environmental Landscapes Corsortium which took over the functions of the then Uraban and Rural Landscaping Section to maintain and embellish specific areas within the Maltese Islands.

Other forms of partnerships took the form of Government roping in a private partner in order to manage specific assets. Concessions on the basis of design, build, operate and finance parameters were given, within the urban regeneration scenario, to the VISET consortium in order to develop and manage a cruise liner terminal; to MIDI to develop Manoel island and Tigne'; to the Cottonera

Waterfront Group and the Port Cottonera Consortium to develop and mange various assets along the Vittoriosa waterfront.

In the healthcare sector, Care Malta Limited was also given a concession for the management of the original Zejtun Residential Home whilst it was subsequently given a DBOF contract for the extension and management of this same home.

With Malta's rapid expansion in various sectors, coupled by the situation of the country's finances, Government may not be in a position to commit the substantial amount of finances that would be required to commission the required facilities. Moreover, the country might not have the experience in the setting up of such facilities. Consequently, the importance and applicability of public private partnerships becomes more attractive.

In the case of waste management, public private partnerships are not a new concept within an international concept. Malta should consider following upon the examples and experience that have been gained by other countries with a view towards placing itself at par with the developments that are required within the sector.

Consequently it is appropriate to consider the applicability of three forms of PPPs namely:

- Design-Build-Operate-Finance (DBOF);
- Concession; and
- Private Finance Initiative (PFI).

After analysing the three aforementioned options, one may conclude that the options can be in reality restricted to two. These are:

- *A combination of DBOF and Concession models:* whereby Government may contribute by providing assets such as land, infrastructure etc and retain the ownership of both the existing and new assets. DBOF Concession often extend for a period of 25 years to 30 years; or
- *PFI* – in this case a Consortium shall be set up. The Consortium shall design, build, operate and finance to operate the waste to energy plant and shall be paid for the services rendered by the Public Sector. Ownership of the asset will be retained by the private sector.

It must be recognised that currently Government does not have the skills, experience or finances to be able to commission this project on its own merits. Moreover, WasteServ Malta Limited should be retained as the operator of last resort so that, should the case arise where, an operator abandons or does not fulfill his/her obligations, then WasteServ would be in a postion to take over the asset in question and operate it thereby providing a relatively uniterrupted service. On the otherhand, what Government can afford is to identify portions of land that can be made available to prospective developers for the construction of the agreed facility.

Therefore, the ideal Public Private Partnership would seek to ensure that Government:

- seeks to source the design, financing and operations of the facility from the private sector;
- provides a portion of land where the facility can be developed;
- determine a minimum guaranteed throughput as well as a minimum capacity requirement for the facility;
- offer the developer a concession for a period of say 25-30 years.

It is in this context that the model combining DBOF and Concession is the most favoured and is being recommended to Government for consideration.

10. Siting Considerations

Studies about the siting and operation of the controlled landfill and also about the alternative sites to the Sant Antnin Composting Plant have already been carried out. Considering Malta's limited land mass, the areas available and the public's negative opinion about the siting of such plants, the available areas are very limited. One has also to take in consideration the policies of the Malta Environment and Planning Authority about such sites. The Waste Management Plan for the Maltese Islands provides a strategic direction in waste management up to 2010.

Policy SWM6 states that "The Planning Authority will assess the suitability of sites for new proposed waste management facilities against the site selection criteria identified in Appendix I of the Waste Management Plan".

Policy SWM 8 states that the Planning Authority will support proposals for the provision and erection of plant and buildings for the recycling, transfer, storage and other treatment or handling of waste provided that:

i) the proposed site is located near to the likely source of waste

ii) the proposed site is located:

- **within an existing industrial site or on land which is permitted or allocated for industry, or:**
- **on land previously used for waste disposal or minerals development, or**
- **at a waste management facility**

iii) the proposal will not give rise to unacceptable impact on local communities or the environment

Policy SWM 16 states that the Planning Authority will support development proposals for composting schemes provided that the proposal will not give rise to unacceptable impact on local communities or the environment. Similarly policy SWM 19 supports proposals for anaerobic digestion plants provided that:

- **there is a source of water**
- **the development is within an area permitted or allocated for industrial development, a site disturbed by development or within or adjacent to an existing waste management facility;**
- **the proposals will not give rise to unacceptable impact on local communities; and**
- **the proposals will deal with residues as an integral part of the operation.**

Policies SWM 8 and 16 would seem to prevent the development of unallocated Greenfield sites.

Policy WDC 3 refers to the requirement for a buffer zone between waste development and proposed sensitive uses. The supporting text refers to an indicative buffer zone of 200 metres between residential dwellings and non-hazardous waste disposal facilities identified in the Environmental Impact Assessment Guidelines.

Policy WDC 4 requires that the site is located close to the strategic highway network, and that the road network can accommodate the anticipated traffic. Policy WDC 5 states that waste management facilities will not be permitted where there would be adverse impacts on:-

- Groundwater resources;
- Sites of Scientific Interest, National Parks and Areas of Ecological Interest;
- Areas of Agricultural Value;
- Areas of High Landscape and Scenic Value;
- Urban and Marine Conservation Areas;
- Sites of Archaeological or Historic Importance;

- o Areas at Risk from Flooding; and
- o Other areas Designated in Local Plans.

10.1 Minerals Subject Plan, February 2002

The minerals industry on Malta is dominated by the extraction of limestone for use in construction. The limestone industry consists of two components;

- o The hardstone industry which extracts Coralline Limestone for use in aggregates; and
- o The softstone industry which extracts Globigerina Limestone for use as building stone.

A mineral resource assessment published in 1996 identified potential mineral resources that are not thought subject to overriding environmental constraints. These sites are safeguarded in the Minerals Subject Plan. Policy HS5 notes that:-

"There is a presumption against the sterilisation of hardstone and softstone resources in the Minerals Safeguarding Areas".

Several areas in Malta have already been studied and these include:-

- Ghallis
- Il-Mara
- Wied Ghammieq
- Zonqor
- Wied iz-Ziju
- Ta Majru
- Benghajsa
- Wied Moqbol

With regards to Gozo, **c**onsidering the small land mass, potential sites that may be considered are:-

- o Transfer Station (Tal-Kus)
- o Ras il-Hobz
- o Il-Qortin

10.2 Siting Options High Level Recommendations

A wide range of factors must be considered in siting a waste management facility. Legal requirements, economical, ecological, geological and hydrological factors, determine some of these. In selecting a site, all relevant factors must be considered as well as current land use, environment, health and transportation. Processing facilities should be away from high population densities and transportation routes to the facility are a major consideration in siting the facility.

Therefore, without prejudice to any planning and environmental procedures and to any further investigations that might be considered appropriate, Government is advised to consider the following facilities located at the sites suggested hereunder:

- o A Mechanical-biological treatment plant (includes the mechanical treatment plant and digester) that we recommend should stay at Maghtab due to traffic movements, land availability, waste management permits, etc;
- o For the RDF, the following options are available:
    - Option 1: thermal treatment plant (incineration/gasification) for the production of electricity as a stand alone facility. This stand-alone facility may be located at an already committed site or elsewhere (not defined).

- Option 2: thermal treatment plant (incineration/gasification) for the production of steam or electricity at Delimara to maximize on synergies with the power generation plants already available and those being planned;

- Option 3: thermal treatment plant (incineration/gassification) for the production of steam for the desalination of water. Potential sites include existing RO sites, that is, Pembroke, Cirkewwa or Ghar Lapsi. WSC need to upgrade their present capacity to improve their water quality and some synergy exists.

o Cognizance needs to be given to the fact that the digestor for the sewage sludge should be located at the site adjacent to the proposed sewage treatment plant for the south of Malta. This gives the opportunity for additional synergies to be developed by utilising the plant to also accept animal husbandry waste from the southern area of the Maltese Islands for treatment.

o Currently, all solid waste, excluding C&D waste, generated from Gozo is transported for treatment to Malta. It must be noted that the organic fraction of such waste comprises of around 50% by weight in water which makes it uneconomical to transport. Consequently, it is being proposed to develop a digestor/gasifier for the treatment of all waste in Gozo in line with the proximity principle. Additional efforts need to be undertaken in order to ensure that separation at source is reinforced in order to deliver as clean a waste as possible to the facility. Moreover, this facility could also treat other waste such as animal husbandry waste as well as sewage sludge from the Gozo wastewater treatment plant. In respect of siting, the Committee advises Government to conduct a site selection exercise in the proximity of the site that is currently earmarked for the development of a transfer station, which development is still being considered by MEPA.

Animal manure is to be treated broadly as recommend by the Agricultural Waste Management Plan for the Maltese Islands possibly merging the sites for treatment of MSW and animal waste when possible in order to improve throughput and avoid site replication.

Thus, initially, the Committee recommends that setting up of two digestion facilities:-

o One at Gozo,which in view of its contained characteristics should offer scope for the integrated treatment of MSW, animal waste and sewage sludge

o One at Maghtab which would also treat MSW, animal waste and sewage sludge but which would also cater for the transfer of the MRF facility from San Antnin in order to allow the 71,000 tonne throughput to be utilised for organic mixed waste.

The development of a third facility to the South of Malta in conjunction with the Malta South of the sewage treatment plant as well as the utilization of RDT should be further developed as Government's infrastructural plans for power generation and sewage treatment materialise.

Appendix A – Definition of PPP Terminology

PPPs recognise that there are some activities that the public sector does best and other activities where the private sector has more to offer. Only by allowing each sector to focus upon what it does best can Government provide the quality services that the public wants and expects. The overall aim of PPPs is therefore to structure the relationship between the public and private sectors in such a way that the activities and risks associated with the specification, delivery and regulation of pubic services are allocated to the party best able to manage them. The following are the types of models that are generally used in this respect.

Design Build (DB)

The traditional public procurement model can be considered as the most basic PPP model. In this model the public sector retains all responsibility and there is very limited risk transfer. Under the Design Build model, the government contracts with a private partner to utilise the services for design and construction of a public facility that conforms to the standards and performance requirements of the government. The construction is financed by the public sector, and once built the government takes ownership and is responsible for the operation of the facility. This model is considered a viable delivery method to procure the future needs for the road transport sector.

Government Applications

Most public infrastructure and building projects, including roads, highways, water and wastewater treatment plants, sewer and water systems, sport arenas and other government facilities.

Advantages

- access to private sector experience;
- opportunities for innovation and cost savings;
- opportunities for increased efficiency in construction;
- reduction in construction time; and
- single point accountability for the owner.

Disadvantages

- reduced owner control; and
- increased cost to incorporate desirable design features or change contract in other ways once it has been ratified

Operation and Maintenance

The government contracts with a private partner to operate and maintain a publicly owned facility. This means an operational and maintenance/service contract involving some level of risk transfer to the private sector for a term of at least five years.

Government Applications

A broad range of government services including water and wastewater treatment plants, solid waste removal, road maintenance, landscape maintenance, recreation facilities, parking facilities and sewer facilities.

Advantages

- potential service quality and efficiency improvements;
- cost savings;
- flexibility in structuring contracts; and
- ownership vests with the government.

Disadvantages

- collective agreements may not permit contracting out;
- costs to re-enter service if contractor defaults; and
- reduced owner control and ability to respond to changing public demands.

Build, Operate, Transfer (BOT)[31]

BOT refers to government contracts with a private partner to design, build and operate a public facility for a defined period, after which the facility is handed back to the public sector. The facility is financed by the public sector and remains in public ownership throughout the contract. The contractor's detailed knowledge of the project design and the materials utilised allows it to develop a tailored maintenance plan over the project life that anticipates and addresses needs as they occur, thereby reducing the risk that issues will go unnoticed and then deteriorate into much more costly problems.

Government Applications

Most suited to projects that involve a significant operating content such as sewer systems, water and wastewater treatment plants or projects.

Advantages

- transfer of design, construction and operating risk;
- potential to accelerate construction;
- risk transfer provides incentives for adoption of whole life costing approach;
- promotes private sector innovation and improved value for money;
- project design can be tailored to the construction equipment and materials that will be used;
- improved quality of operation and maintenance;
- contracts can be holistic; and
- government able to focus on core public sector responsibilities.

Disadvantages

- possible conflict between planning and environmental considerations;
- contracts are more complex and tendering process can take longer;
- contract management and performance monitoring systems required;
- cost of re-entering the business if operator proves unsatisfactory; and
- does not attract private finance and commits public sector to providing long term finance.

The public sector awards BOT contract by competitive bid following a transparent tender process. Tenderers respond to the specifications provided in the tender documents and are usually required to provide a single price for the design, construction and maintenance of the facility for whatever period of time is specified.

Design, Build, Operate (DBO)

Government provides the financing for the project but engages a private partner to design, construct, operate and maintain the facility for a specified period of time. Performance operatives are established by the public sector and the public partner maintains ownership of the facility throughout. This form of PPP is applicable where the public sector maintains a strong interest in ownership but seeks to benefit from private construction and operation of a facility.

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[31] BOT is sometimes referred to as Turnkey operation.

Government Applications

This would include most infrastructure facilities, including water and wastewater treatment plants, arenas, golf courses and government buildings.

Advantages

- o places construction risk on the private partner;
- o proposal call can control design and location requirements as well as operational objectives;
- o transfer of operating obligations can enhance construction quality;
- o potential public sector benefits from increased efficiency in private sector construction;
- o potential public sector benefits from increased efficiency in private sector operation of the facility like for example ongoing maintenance of the plant and equipment; and
- o construction can occur faster through fast-track construction techniques such as Design-Build.

Disadvantages

- o reduced government control over facility operations;
- o more complex award procedure;
- o increased cost to incorporate changes in design and operations once contract is completed; and
- o depending on the type of infrastructure, financing risk may be increased by the government.

Design, Build, Operate, Finance (DBOF) Concession

The primary vehicle for PPP opportunities involving direct private sector investment is the DBOF concession agreement. This involves a contractual relationship between a public sector body and a private sector contractor for the design, building, operating and financing of an already existing public facility/infrastructure for a defined period, after which ownership of the facility reverts to the public sector. The facility is owned by the private sector for the contract period and the private sector contractor recovers its costs mainly out of payments from the public sector. The key driver of this model is the utilisation of private finance and transfer of design, construction and operating risk.

Government Applications

This would include most infrastructure and other public facilities, including roads, water systems, sewer systems, water and wastewater treatment plants, and recreation facilities.

Advantages

- o attracts private sector finance;
- o public sector does not have to provide capital funding for the upgrade;
- o financing risk rests with private partner;
- o public partner benefits from the private partner's experience in construction;
- o opportunity for fast-tracked construction using techniques such as Design-Build;
- o flexibility for procurement;
- o opportunities for increased efficiency and acceleration in construction; and
- o time reduction in project implementation.

Disadvantages

- o future facility upgrades not included in the contract with the private partner may be difficult to incorporate at a later date;
- o expense involved in alteration of existing contract with the private partner;
- o perceived loss of control;
- o contacts are more complex and tendering process can take very long; and

- a change management system together with contract management and performance monitoring systems are required.

Concessions

Concession contracts are similar to DBOF arrangements and can be awarded for the construction of a new asset or for the upgrading or expansion of an existing facility. These agreements enable a private investment partner to finance, construct and operate revenue generating infrastructure improvement in exchange for the right to collect the associated revenues for a specified period of time, either through direct user charges or through a mixture of user charging and public subventions. Under a concession approach, the ownership of all assets, both existing and new, remains with the public sector. Concessions often extend for a period of 25 to 30 years or even longer and are awarded under competitive bidding conditions.

Government Applications

Concessions are generally awarded based on the end price offered to users, the level of financial support required from the government and the ability to implement the project. Concessions are most suited to projects that provide an opportunity for the introduction of user charging like for example, roads, water (non domestic) and waste projects.

Advantages

- Same advantages of DBOF and additional increased level of demand risk transfer and encourages generation of third party revenue.

Disadvantages

- Same disadvantage of DBOF and in addition;
- May not be politically acceptable; and
- Requires effective management of alternatives / substitutes e.g. alternative transport routes or alternative waste disposal options.

Design, Build, Finance (DBF) or Lease-Purchase

The government contracts with the private partner to design, build and finance a facility to provide a public service. The private partner may then lease the facility to the government for a specified period of time and under predefined conditions. The private sector is not responsible for any operation or maintenance.

At the end of the lease agreement the private partner will cede any interest in the asset to Government who shall assume ownership of the asset in its entirety. This approach can be taken where government requires a new facility or service but may not be in a position to provide financing.

Government Applications

This can be used for capital assets such as buildings, vehicle fleets, water and wastewater treatment plans, solid waste facilities and computer equipment.

Advantages

- improved efficiency in construction;
- opportunity for innovation;
- impact on balance sheet is dampened as this reflects the lease payments as opposed to the capital cost of construction;
- improve services available to residents at a reduced cost; and
- potential to develop a “pay for performance” lease.

Disadvantages

- reduction in control over service or infrastructure.

Temporary Privatisation

Ownership of an exiting public facility is transferred to a private partner who improves and/or expands the facility. The facility is then owned and operated by the private partner for a period specified in a contract or until the partner has recovered the investment plus a reasonable return.

Government Applications

This model can be used for most infrastructure and other public facilities, including roads, water systems, sewer systems, water and wastewater treatment plants, parking facilities, local government buildings, airports and recreation facilities such as sports complexes

Advantages

- if a contract is well structured with the private partner, government can retain some control over standards and performance without incurring the costs of ownership and operation;
- the transfer of an asset can result in a reduced cost of operations for the government;
- private sector can potentially provide increased efficiency in construction and operation of the facility; and
- operational risks rest with the private partner.

Disadvantages

- perceived or actual loss of control;
- initial contract must be written well enough to address all future eventualities;
- private sector may be able to determine the level of user fees, which they may set higher than when under government control;
- difficulty replacing private partner in the event of a bankruptcy or performance default;
- potential for government to re-emerge as the provider of a service or facility in the future;
- displacement of government employees; and
- labour issues in transfer of government employees to the private partner.

Build, Own, Operate (BOO)

The government either transfers ownership and responsibility for an existing facility or contracts with a private partner to build, own and operate a new facility in perpetuity. The private partner generally provides the financing.

Government Applications

Most public infrastructure and facilities, including water and wastewater systems, parking facilities, recreation facilities, airports, local government administration and operations buildings.

Advantages

- no public sector involvement in either providing or operating the facility;
- public sector can “regulate” the private sector’s delivery of a “regulated” service area;
- private sector operates the service in the most efficient manner, both short-term and long-term;
- no public sector financing is required;
- income tax and property tax revenues are generated on private facilities, delivering a “public good”; and
- long-term entitlement to operate facility is incentive for developer to invest significant capital.

Disadvantages

- commercial operational and construction considerations may conflict with the social and civic responsibilities;

- o the public sector has no mechanism to regulate the "price" of the service, unless it is a specifically regulated commodity[32]; and
- o no competition, therefore necessary to make rules and regulations for operations and to control pricing.

Build, Own, Operate, Transfer (BOOT)

The private developer obtains exclusive franchise to finance, build, operate, maintain, manage and collect user fees for a fixed period to amortise investment. At the end of the franchise, title reverts to a public authority.

Government Applications

Most infrastructure services and facilities, including water and wastewater systems, recreation facilities, airports, local government administration and operations buildings, parking facilities and solid waste management facilities.

Advantages

- o maximizes private sector financial resources, including capital cost and allowance;
- o ensures that the most efficient and effective facility is constructed, based on life-cycle costs;
- o allows for a private sector operator for a predetermined period of time;
- o the community is provided with a facility, without large up-front capital outlay and/or incurring of long-term debt;
- o all "start-up" problems are addressed by the private sector operator;
- o access to private sector experience, management equipment, innovation and labour relationships may result in cost savings; and
- o risk shared with private sector.

Disadvantages

- o facility may transfer back to the public sector at a period when the facility is "work" and operating costs are increasing;
- o public sector loses control over the capital construction and initial mode of operations;
- o initial contract must be written sufficiently well to address all future eventualities;
- o the private sector can determine the level(s) of user fees (unless public sector subsidizes use);
- o less public control compared to Build-Operate-Transfer structure; and
- o possible difficulty in replacing private sector partner or determining agreements if bankruptcy or performance default.

Lease, Develop, Operate or Buy, Develop, Operate

The private partner leases or buys a facility from the government, expands or modernizes it, then operates the facility under a contract with the government. The private partner is expected to invest in facility expansion or improvement and is given a specified period of time in which to recover the investment and realise a return.

Government Applications

Most infrastructure and other public facilities, including roads, water systems, sewer systems, water and wastewater treatment plants, parking facilities, government buildings, airports and recreation facilities such as arenas and sports complexes.

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[32] This can be mitigated against at the onset with appropriate safeguards being built in the Build, Own, Operate (BOO) contract between Government and the Public Sector and that stipulate the maximum price that can be charged by the private partner.

Advantages

- if private partner is purchasing a facility, a significant cash infusion can occur for government;
- public sector does not have to provide capital for upgrading;
- financial risk can rest with the private partner;
- opportunities exist for increased revenue generation for both partners;
- upgrades to facilities or infrastructure may result in service quality improvement for users;
- public partner benefits from the private partner's experience in construction;
- opportunity for fast-tracked construction using techniques such as Design-Build; and
- time reduction in project implementation.

Disadvantages

- perceived or actual loss of control of facility or infrastructure;
- difficulty valuing assets for sale or lease;
- issue of selling or leasing capital assets that have received grant funding;
- if a facility is sold to a private partner, failure risk exists – if failure occurs, government may need to re-emerge as a provider of the service or facility; and
- future upgrades to the facility may not be included in the contract and may be difficult to incorporate later.