Request For Proposal for
Waste Characterization Study

Sorouh Energy

1st November 2022

Rev.	Purpose of Issue	Date	Originator	Approved
1.00	Request to Bidders Jenin	1st Dec 2021	Mr. Rijswijk	Mr. Ayyad
2.00	Request to Bidders Jenin	23rd Dec 2021	Mr. Rijswijk	Mr. Ayyad
3.00	Internal version Sorouh Energy	N.A.	N.A.	N.A.
4.00	Request to Bidders Jenin	1st Nov 2022	Mr. Rijswijk	Mr. Ayyad

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1 Definitions

Abbreviation or Term	Definition
Bidder	A business entity or consortium that submits its Proposal according and in response to this RFP
Consultant	The selected Bidder selected, bound by a signed contract
FIDIC	International Federation of Consulting Engineers
IFC	International Finance Corporation
Price	Total cost of the Proposal, containing all related costs for all the work required
Proposal	The offer made by the Bidder according to this RFP, for consideration or acceptance
RFP	Request for Proposal
Sample	Refers to a bulk sample taken from a single garbage collection
SPV	Special Purpose Vehicle (project company)
WtE	Waste-to-Energy

2 Project Background

The company Sorouh Energy – formerly known as 'the Northern Consortium' – consisting of strong and knowledgeable partners in the field of Waste-to-Energy (WtE) plants, has the ambition to develop and construct a world-class "beyond Best Available Technology" facility in Jenin, with a capacity of processing around 1,200 tons of waste per day (the Project). The proposed plant will produce around net 35-40 MW (~310 GWh) of electricity to be sold to the grid, depending on the caloric value of the waste.

In March 2021, the Northern Consortium (now called Sorouh Energy) finished first in the Palestinian Authority Ministry of Local Government international tender Project No. MOLG2020-1/20. The project was awarded subject to conditions in Q3 2021 (award letter can be provided on request). The SPV currently negotiating the project contracts for the waste concession and power purchase agreement (PPA). As soon as these are completed, the feasibility studies will start.

Sorouh Energy is specifically set up to pursue opportunities in Palestine to develop WtE plants with Harvest Waste's[1] High Efficiency WtE technology based on and similar to the AEB WtE plant in Amsterdam, The Netherlands. This reference plant uses the world's most efficient technology for generating electricity from waste and it will treat the current and future municipal solid waste of Jenin. WtE technology minimizes land requirements and produces baseload clean energy. In addition to that, the remaining slag from the incineration process can be recycled to further reduce landfills and provide valuable inert materials and metals for the construction industry.

The waste characterization study is a key input parameter for the WtE plant design and directly affecting the project feasibility. For this Project, Sorouh Energy requests a waste characterization study on municipal solid waste to be conducted in preparation for the construction and operation of a Waste-to-Energy plant in the Jenin Governorate, in the Palestine Territories. An indication of the assignment duration would be around 6 months.

The waste characterization study shall be executed according to the standards and protocols as prescribed in this RFP. The study shall be executed in close cooperation with and under supervision of Sorouh Energy. Therefore, Sorouh Energy (hereafter "SPV") is requesting Proposals from accredited consulting firms in performing a waste characterization study.

For any further information please contact

Name: Mr. Lars Rijswijk
Email: l.rijswijk@harvestwaste.com
Tel: +31650224330

[1] www.harvestwaste.com

3 RFP Outline

3.1 Objective

In general, the objective of a waste characterization study is to define the composition, resulting in the calorific (energetic) value and chemical composition of the waste. This value is a key variable for a valid business case of the WtE plant. A waste characterization study ensures that:

- The composition of the waste is determined according to valid methods.
- The calorific (energetic) value, moisture content of the waste and its chemical composition is known.
- Type and combustion properties for all sorts of the waste arising are identified based on representative samples determined in cooperation with the JSC and SPV.

To get as accurate results as possible, this research will be repeated in the future. In this RFP Bidders are requested to run two campaigns. One in the dry season and one in the wet season.

Because the SPV concludes contracts[2] for a 25-year period, it is necessary to make the best possible prediction about the future development of the waste composition as well. That is why, parallel to this waste characterization study, a waste development study is requested. The joint results - together with a periodic repetition of the waste characterization study – will allow the SPV maintain a tenable picture of the current and future waste composition and accurately validate assumptions in line with the project business case.

The study shall be executed in close cooperation with and under supervision of technology provider of Sorouh Energy (Harvest Waste).

[2] Power Purchase Agreement (PPA) and Waste Concession (WC)

3.2 Award criteria

Section	Criterium	Max. points
1 – Minimum administrative requirements	**Pass – Fail** All requirements must be met by the Bidder[3]. If one item will not be met, the Proposal will not be evaluated.	N/A
2 – Technical Proposal	**Project Approach** Bidder to provide a description of its company[4] and project approach, including a project schedule with a visible critical path. Milestones, stipulated in the previous paragraph, must be included in the schedule. If the Bidder decides to participate as a consortium, the split of scope must be made known. The project approach will be assessed in conjunction with the planning.	25
	Project references Bidder to provide references. The better these references match with the TOR of this RFP, the higher this item will be valued.	25
	Project team Bidders' proposed project team and CV's will be evaluated on applicable references	25
3 – Financial Proposal	**Price level** The lump sum price in USD. The award of points is made relative to the lowest price. Best bidder gets 25 points. The % deviation from the lowest price is also the % that is deducted from 25 points. Calculation example below	25

Calculation example award of points for financial proposal

Bidder 1	–	*USD 100,000 – lowest bidder = reference for calculation*	-	*25 points*
Bidder 2	–	*USD 120,000 – 20% higher than lowest bid*	-	*20 points*
Bidder 3	–	*USD 150,000 – 50% higher than lowest bid*	-	*12,5 points*

[3] Bidder is allowed to participate as a Consortium. In that case, the minimum administrative requirements must also be met by the subcontractors
[4] Bidder to include company quality standards like ISO9001/14001/45001, if applicable

4 Data sheet

Sorouh Energy will provide the following project information as a part of this RFP, as input for the Bidders' Proposal:

- Feasibility Study Waste-to-Energy options on the West Bank, November 18th, 2018
- SPV's bid proposal for Jenin, including (amongst others)
- Preliminary Waste Acceptance criteria

All information provided will be verified and validated during feasibility phase. The assumptions, assessments, statements, and information contained in this Data sheet, may not be complete. This information may only be used to develop a Proposal.

For study results and reporting, each Bidder should, therefore, conduct its own investigations and analysis and should check the accuracy, adequacy, correctness, reliability and completeness of the assumptions, assessments, statements, and information contained in this Data Sheet and obtain independent advice from appropriate sources.

This Data sheet information set is provided in Annexure I

5 Terms of Reference (TOR)

This TOR is the basis for the request for proposal, consultancy agreement and the final study results. The TOR consists of three elements:

1. **Scope of Work and Reference Framework** provides a non-exhaustive list of activities to be performed by the Consultant and criteria, standards, and guidelines against which the Consultant must assess the project.
1. **Deliverables & Milestones** specifies the minimum requirements that reports and results must comply with..
2. **Project Management** prescribes what SPV expects from Consultant with regard to basic project management areas like progress reporting, planning, variations management, etc.

5.1 Scope of Work and Reference Framework[5]

This waste characterisation scope of work is to be carried out over two separate campaigns to provide an indication of waste quality changes due to seasonal extremes. For Jenin, the extreme seasons are considered as being:

- Dry season - June - August
- Wet season - Dec to January

The work is to be planned and subsequently executed in the following sequence:

A short description is herein provided for each step in the sequence. It is the intention of Sorouh Energy to formalize this sequence into a robust procedure that can then be carried out at regular intervals during the construction and operation of the plant for the purpose of monitoring and adapting to changes in waste composition over time. Contracts for the long-term provision of waste characterisation studies is beyond the intent of this RFP and will be addressed at a later date.

During the initial campaign, Sorouh Energy will provide access to a third-party consultant who can provide training / advice for each step. The third-party consultant will also be responsible for reviewing and approving plans / reports on behalf of Sorouh Energy.

The following sections describe the expectations for each step.

[5] For all references, the current version applies

5.1.1 Step 1 - Source Categorisation

To obtain a good estimation of the waste population in each location, Consultant is expected to categorise where the waste is coming from using a standard framework. Key categories are:

- Urban/rural area
- High/medium/low income
- Residential/commercial area
- Retail / Industrial commercial

This information will be used to obtain a good estimation for the population of all waste in the locale and determine the specific areas where the Consultant must obtain waste samples for testing and analysis. The categorisation must also be used within the sample tracking system to ensure that any final results from testing and analysis can be linked to the original source of the waste.

Source categorisation will be carried out by the Consultant. Sorouh Energy and its third-party consultant will be available to advise. Once the categorisation work is complete, the Consultant must present to SPV for agreement / approval.

Breakdown:

1. At least three major categories should be defined and will reflect the typical sources of received waste.
2. The proportion of waste received from each category shall be calculated and defined as a percentage of the total

For example:

Simple distribution	Further Detail
63% Urban	City centre, mainly residential & medium income households
25% Rural	100% residential suburbs and small villages / settlements
12% Commercial	Retail stores / restaurants etc. no industrial or office waste

Note. The further detail will depend on the availability of information from the waste collection company and is not necessary for the initial campaigns

5.1.2 Step 2 - Waste Sampling

Once the main categories have been identified, the next step is to define the number of samples in each category that are to be obtained, sorted and analysed.

For each category, SPV considers that a collection is a garbage truck load from a specific route. From each collection, a mass of approximately 700kg is to be taken. This is to be defined as the Sample.

Breakdown (continued):

3. For the smallest category, at least two collections are to be taken from different days of the week, resulting in at least two Samples of 700kg

4. For the remaining categories, the number of Samples should increase in line with the % distribution and the collection days should be spread across the week. The total number of Samples across all categories should be no more than 16.

To continue the example above, the table below shows a typical campaign

	Collections / Samples							
Simple distribution	M	T	W	T	F	S	S	Total
63% Urban	2		2	2		2	2	10
25% Rural		2					2	4
12% Commercial		1		1				2
							Grand Total	**16**

5.1.3 Step 3 - Waste Sorting

For each Sample, manual sorting shall be carried out for the determination of the biomass content of solid recovered fuels and moisture content.

Breakdown (continued):

5. For each Sample, the waste is to be split into suitable containers (recommend 240l trashcan) and net weight is to be recorded prior to sorting.

6. Each 240l container will be individually sorted into the relevant fractions. Guidance will be given on this step as it is essential that sorting into fractions is carried out using a common method. The fractions to be sorted are as follows:

#	Fraction	#	Fraction
1	Paper / Cardboard	10	Diaper sanitary towels
2	Wood	11	Tetra Brik
3	Other organic materials	12	Other combustible materials
4	Textile	13	Hazardous waste
5	Rubber	14	Electric & electronic waste
6	PP >5cm	15	Other metals
7	HDPE > 5cm	16	Glass
8	PET 5>cm	17	Other inert materials such as stone, debris, pottery
9	Other plastics >5cm		

7. On completion of the sorting, the total net weight of each fraction is to be individually recorded. The result can then be used to calculate the bulk composition (mass balance) as well as the moisture content of each Sample.

At this point, fractions 13 to 17 (which will not be analysed in the laboratory) may be discarded.

5.1.4 Step 4 - Laboratory Sample Preparation

The next step will be to take a representative quantity of each fraction for laboratory analysis.

Breakdown (continued):

8. From each of the remaining fractions within the Sample, a quantity of waste to be taken and prepared for analysis. Typically, one 60l sealable bag for each fraction is used as a representative quantity.

Preparation for testing and analysis will differ according to each test to be carried out and will therefore not be detailed here. Instead, preparation and testing shall be executed according to the methods referenced in EN15443 “methods for sample preparation of solid recovered fuels”. Moisture loss during sample preparation shall be reported.

5.1.5 Laboratory Sample Analysis

The final step will be to carry out testing and analysis for the following properties:

Breakdown (continued):

9. For each representative quantity of sorted fractions, tests are to be carried out to determine the following properties:
    - Ash content
    - Moisture content
    - Lower Heating Value (LHV)

This concludes the standard sequence of events for each of the 16 collections / samples within each waste characterisation campaign (dry season and wet season). However, for each of the categorized areas in the first campaign (in our example this is Urban, Rural and Commercial) an additional testing round is desirable to determine the chemical composition of each of the fractions.
The selection of the specific collection / Sample is to be made at random and only fraction number 1 to 12 should be tested. This will mean that from the entire campaign of 16 collections / Samples, 3 sets of 12 fractions are to be analysed for the following chemical components:

- Chlorine
- Sulphur
- Hydrogen
- Oxygen
- Nitrogen
- Carbon

Note. To keep track of all samples and maintain a link from collection to final test results, a robust numbering / labelling system is to be employed. The Consultant is required to propose a suitable system. Sorouh Energy, has employed a suitable numbering system for tracking and reporting within a previous project and will be available to advise as necessary.

5.2 Deliverables and Milestones

Activity	Deliverable / result[6]	Minimum Requirement	Milestone
Kick off meeting	Workshop		M1 *t = 0*
Source categorisation	Presentation		*t + 2 weeks*
First Campaign	Interim report	According to paragraph 5.2	M2 *t + 6 weeks*
Second Campaign	Presentation		M3 *t + 32 weeks*
Final Report	Final report	According to paragraph 5.2	M4 *t + 35 weeks*

Milestones for second campaign and final report can be subject to further discussion

5.2.1 Minimum reporting requirements

<u>**Interim report** (after first sampling campaign)</u>
An interim report is required after completion of the first sampling campaign. The report is to provide details of the agreed method employed for each process step as well as the results obtained. The final format of the report can be agreed during execution of the work but must, as a minimum include:

a) Source categorisation summary
b) Waste sampling process
    - Description of sampling method
    - Description of sampling preparation methods
    - Description of manual sorting method
    - Description of analysis methods
c) Waste characterization
    - Bulk composition resulting from manual sorting per sample in weight percent as received base for each analysed sample
    - Moisture loss during sorting needs to be recorded per sorted sample
    - Bulk composition resulting from manual sorting per sample on a dry base for each analysed sample

[6] According to reference framework

- Moisture content per fraction corrected for moisture loss during sample preparation for each analysed sample
- Chemical components and content as received per fraction for each analysed sample
- Lower heating value as received via bomb calorific value determination method per fraction-moisture loss during sample preparation for each analysed sample, should be reported separately and shown in the final LHV calculations.
- Ash content per fraction corrected for moisture loss during sample preparation for each analysed sample

Additionally, all analysis results should be summarized in an Excel-sheet, format for this excel sheet will be provided by Sorouh Energy after award.

Final report (after second sampling campaign)
Upon completion of the second campaign, a full report is to be provided and is to follow the same format as the interim report with the addition of a comparative analysis of the waste quality / composition between the two campaigns.

5.3 Project Management

5.3.1 Project reporting

In general, project baselines define starting points for

- project scope (according to this RFP)
- project schedule (based on the RFP milestones)
- project cost (financial proposal)

These baselines are fixed reference points to measure and compare the project's progress against. This allows SPV to assess the performance of the project over time. Any proposed changes to a baseline document, will be subject to variations management.

As a minimum, a formal monthly progress report is requested for:

- Project progress, Summary of last developments and next steps, in brief wording
- Project schedule: schedule baseline vs actual and a forecast
- Project risks Log: top 3-5 risks, including suggested mitigations and impact value
- Project variations Log: variations requests status impacting budget & schedule

The SPV will hold weekly update meetings with the Consultant. This will be done online or live, subject to availability.

The reporting template is provided in Annexure IV.

5.3.2 Project Scheduling

The project schedule must serve to:

- represent how and when the project will deliver the project scope
- serve as a tool for communication and managing stakeholders' expectations
- serve as a basis for performance reporting

The Consultants' project schedule must be made available in editable format, preferably in Microsoft Projects, Excel or comparable

5.3.3 Variations management

The Consultant may request a change. Issues, found while the project work is performed, could lead to a 'variation'[7], and may modify any deliverable of project baseline and requires a variations request, to be made by the initiator.

Only approved variations may be executed and, after approval, will be incorporated into a revised baseline. Inspections can be used to verify whether a variation request has been followed up according to the approval.

[7] As specified in FIDIC White (5th Edition)

6 Proposal requirements

The language of the proposal must be in English. The Bidders' proposal must consist of the following three sections

6.1 Minimum Administrative Requirements

Proposals which comply with minimum requirements and criteria will be the subject to evaluation. Minimum administrative requirements will be evaluated using 'pass or fail' criteria. If one of these requirements is not met, Sorouh Energy holds the right to not evaluate the Proposal. The list of administrative requirements is provided in Annexure II. Bidder will have to provide a signed version of Annexure II.

6.2 Technical Proposal

Type	Requirement	Proof (free format)
Project Approach	- A description of the methods applied, applicable standards, the proposed management structure, how it plans to ensure the quality of its performance; and its capability to quickly mobilize required experts. - A project schedule, specified in weeks, including visible critical path and milestones - If the Bidder decides to participate as a consortium, the consortium members and split of scope must be made known.	Description Gantt chart Consortium companies, split of scope
Project References	- Demonstration of experience in similar projects for (international) financial Institutions like IFC, the World Bank or Asian Development Bank	Reference list, for each project, include: - Project description - Client name - Start date & completion date
Project team	- Project team lead - Suitably qualified personnel required to perform the contract. Indication of specialists. Combined roles may be performed by one person	- Organogram of the project organisation - CV of Project Manager and project team members

6.3 Financial Proposal

6.3.1 Financial proposal outline

Bidder must include a financial section, with the following content:
- The Price, based on lump sum
- A breakdown of the Price in separate cost items according to the items in paragraph **Error! Reference source not found.** with specification of hourly effort of each project member.
- Its liability cap to the SPV, expressed in USD amount and as percentage (%) of its lump sum proposal.
- Standard hourly rate tables for consideration due to variations

6.3.2 Payment Milestones

#	Description	Deliverable	Payment
M1	Kick off meeting	Minutes of the workshop	30%
M2	Interim report	Report after 1st campaign	20%
M3	Draft report	Presentation after 2nd campaign	20%
M4	Final report	Final report	30%

The final payment term is set on 30%. This expresses the importance for the SPV to obtain the final report, according to schedule.

Annexure I – Data sheet

Feasibility study
Waste to Energy options for the West Bank, Palestine

November 18th, 2018

An assignment for the Rijksdienst voor Ondernemend Nederland (www.rvo.nl)

ETFP18006

Rijksdienst voor Ondernemend Nederland

BreAd B.V.

expert

Mr. Hans Breukelman is a chemical engineer with a long track record in waste management, wastewater treatment and soil remediation. He has worked for private companies such as DSM Research BV, Attero and Essent Environment, public authorities (e.g. Province of Overijssel) as well as at NGO's such as the National Foundation for Nature and Environment. Currently he runs his own company called BreAD B.V., providing international environmental consultancy services, business development and interim management in the waste management and sustainable energy field.

List of abbreviations

SWM	Solid waste management
WtE	Waste to Energy
JSC	Joint Service Council
MoLG	Ministry of Local Government
PENRA	Palestinian Energy and Natural Resources Authority
EQA	Environmental Quality Authority
PERC	Palestinian Energy Regulatory Council
PETL	Palestinian Energy Transmission Limited
DISCO's	Electricity distribution companies
JICA	Japan International Cooperation Agency
NRO	Netherlands Representative Office
GHG	Green house gas
CHP	Combined heat and power production
LCOE	Levelised cost of electricity
CDW	Construction and demolition waste

0. Summary

A study was conducted on assessing the feasibility of three Waste-to-Energy options on the West Bank. The options include (i) enhanced extraction and electrification of landfill-gas, (ii) digestion of biowaste combined with electrification of the resulting biogas and (iii) direct bulk incineration of municipal waste. The assessment was completed by including a non-energy option, being composting of biowaste, as a reference.

The assessment included financial, technical, institutional and other aspects. The conclusion is that direct incineration has the highest potential with regard to production of electricity but has some serious drawbacks with regard to needed minimum scale, needed capital and resulting LCOE (levelised cost of electricity). On the other side of the spectrum is enhanced landfill gas extraction with a low potential but equally low needed capital and resulting LCOE. Digestion turns out to give a high LCOE combined with a number of other downsides.
The advise would be:

- Implement landfill gas extraction and electrification irrespective of other scenarios to be chosen.
- Further weigh and discuss all aspects of direct incineration within the context of the West Bank situation.
- When choosing not to implement incineration, consider the stepwise introduction of separate collection and composting on the regional level.

The results were presented and discussed at a workshop in Ramallah on November 14th.

1. Introduction

The West Bank faces tremendous challenges. The Palestine authorities are building up civil services under complex circumstances. Poor financial resources, restricted land-use and important controls on resources and transport in the hands of Israel are a few of the most important constraints.

Electricity services are nearly at 100% coverage and availability, but the dependency on Israeli deliveries and transport is high. The Palestine government is trying to reduce this dependency by investing in an autonomous production capacity through PV and is thinking of other renewable and sustainable sources.

Waste management is one of the other services that need to be brought to a higher level. The West Bank is improving its waste collection and closing down illegal dumpsites but the effect up until now is that the growing quantity of collected waste has to be disposed of in just a few landfill sites.

In this situation the thought of producing energy from waste is not far away. The authorities have high expectations of the potential and these expectations are fuelled by proposals of private companies promising WtE (waste to energy) concepts at low costs.

In February of this year contacts between the special Dutch envoy Tessa Terpstra and PENRA, the Palestine Energy and Natural Resources Authorities, lead to the conclusion that Palestine is in need of a feasibility assessment of WtE options that have come to the table until now. It should provide an overview and give advise for first steps forward with regard to the most fitting and feasible technology under Palestine circumstances.

This report is the result of this feasibility study. It is based on data research and a number of interviews and visits as described in annex 1.

Chapter 2 summarises the relevant aspects of the West Bank and its waste and energy situation. Chapter 3 describes possible technologies and the next chapter evaluates their feasibility. In this evaluation also institutional aspects are considered. The report finishes with conclusions and advises in Chapter 5.

The slides of the presentation at the workshop of November 14th are given in annex 7.

2. Present situation

2.1 General aspects

Geography and natural resources

This report focuses on the West Bank being the largest of the two Palestine territories in Israel. The territory is bordered by Israel on the North, West and South-side, and by the Jordan river, the Dead Sea and Jordan on the East-side.

The Palestinian sun provides 3000 sunshine hours with an intensity of 2,63 kWh/m2.day in December and 8,4 kWh/m2.day in June. Average monthly temperatures range between a minimum of 5 ^{0}C and a maximum of 30 ^{0}C. Average yearly rainfall is around 450 mm with a remarkable variation ranging from 150 mm in Jericho to over 700 mm in Ramallah.

An important issue when it comes to thermo-electrical power production is the availability of water bodies that can be used for the use as source for steam and cooling water. The West Bank lacks this needed resource and as a result cooling has to be performed through dry cooling.

Demographics, economics and industry

According to the 2017 census the territory is home to 2.881.687 Palestinians distributed over 11 governorates as shown in map 1[1]. The average household size is 4,8 persons per household. The population grows at an estimated 2%.

GDP (ppp) in the Palestinian territories (including Gaza strip) in 2014 was at $ 4.300 per capita[2] with a growth in the last years dropping to around 3%[3]. Average net salaries are $ 25-30 per day. The currency is the New Israeli Shekel with a rate of € 0,234 per 1 NIS and $ 0,271 per 1 NIS. In the financial paragraphs of this report both Euro and NIS will be used.

There is practically no demand for heat, neither for domestical nor for industrial use. This means that thermo-electrical production on the West Bank should be electricity-only with no chance for CHP (combined heat and power).

Political situation

The situation on the West Bank can not be understood without shortly describing the troublesome governance situation as illustrated in map 1[4]. The situation is a direct result of the Oslo Accords, dividing the West Bank into 3 major designated areas being:

- Area A - About 18% of the West Bank, comprising eight Palestinian cities and their municipal areas; in this area both security and civil authority rests with the Palestinian authorities.
- Area B - About 22% of the land including around 440 Palestinian villages in which Civil authority rests with the Palestinians but security control is a shared Israeli-Palestinian responsibility.

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[1] Palestinian Bureau of Statistics (PCBS) http://www.pcbs.gov.ps

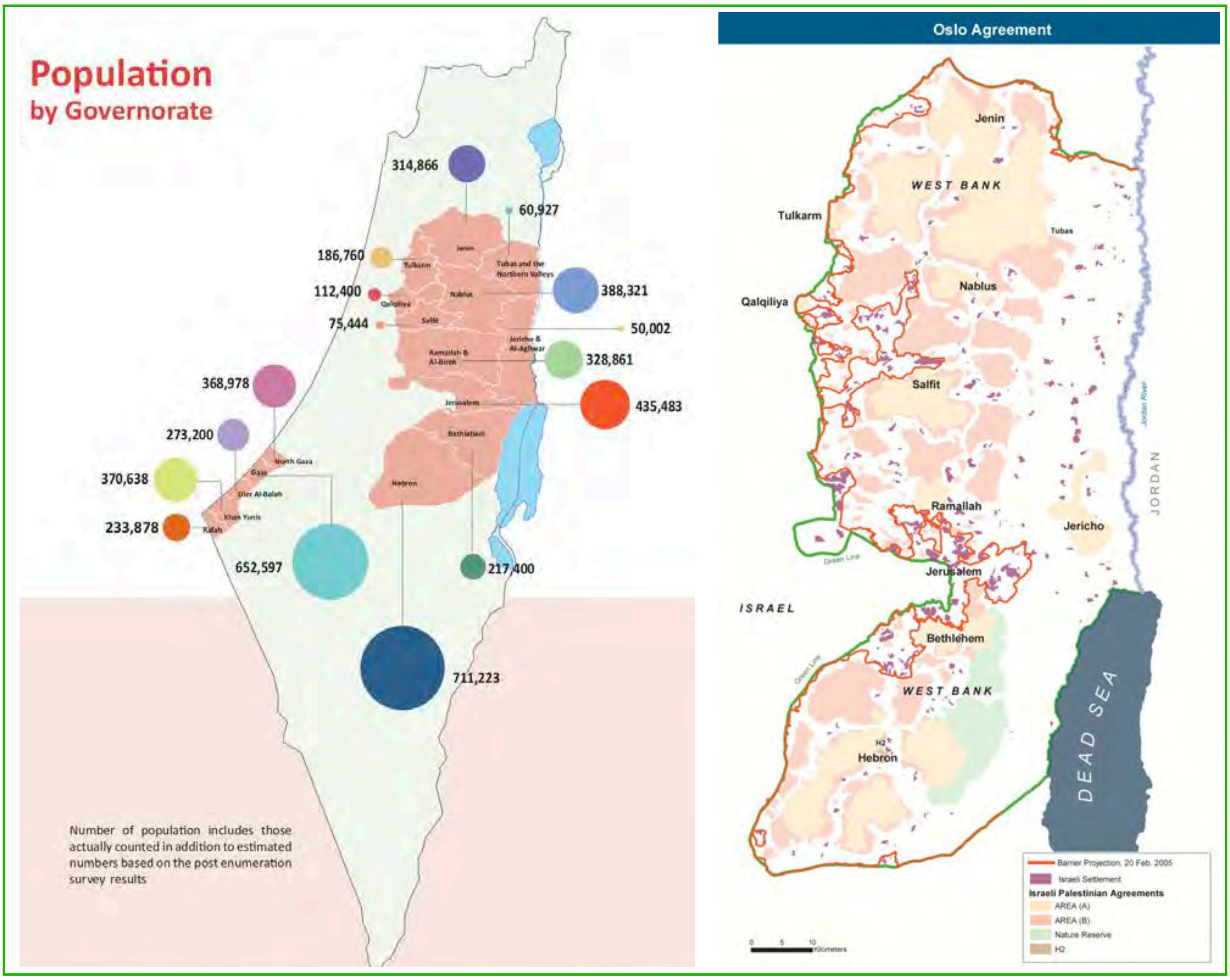
[2] theodora.com/wfbcurrent/west_bank_economy.html

[3] Worldbank, Palestine's economic outlook, april 2018

[4] Source map: wikipedia

• Area C - The remaining 60% is still under the security and civil authority of Israel.

The consequences of this division are fundamentally influencing daily live as free transport of people, goods and services are seriously inhibited. This certainly also holds for the delivery of waste and electricity services to the public.



MAP 1. GOVERNORATES, POPULATION AND AREA'S ACCORDING TO OSLO ACCORDS

2.2 Waste

Production and composition

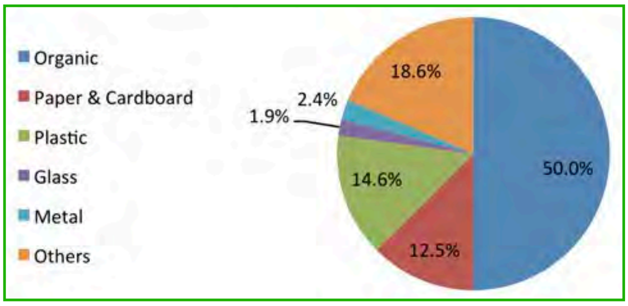
Waste, in this report, is defined as municipal solid waste as it is collected by municipal collection services. It includes the waste of households, city cleaning, small shops, offices, hotels etc. The average waste production per inhabitant per day is around 0,81 kg leading to a total daily production of around 1950 tons or 720.000 tons per year[5].

Waste production tends to grow with the growth of the population (with elasticity-ratio 1), of the economy (at elasticity-ratio around 0,5) and of the degree of urbanisation. When using the data from paragraph 2.1 and neglecting the influence of urbanisation, the annual growth of the waste production can be estimated to be 3,5%. The projected waste production in the upcoming 15 years can thus be calculated as shown in table 1, showing an increase of almost 70%.

Year	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032
Waste production 1000 tons/year	720	745	771	798	826	855	885	916	948	981	1016	1051	1088	1126	1165	1206

TABLE 1 PROJECTION OF ANNUAL WASTE PRODUCTION

The composition of waste on the West Bank, as provided by the JICA data book, is summarised in the pie chart of Graph 1.



GRAPH 1 AVERAGE WASTE COMPOSITION ON THE WEST BANK

This graphic shows an organic content of 50% providing a good potential for composting and digestion and for the production of landfill-gas when this waste is landfilled. Paper, plastics and metals seem to be promising too, however it must be stated that only source separation may lead to good quantities and qualities that are fit for recycling.

With regard to WtE options, and especially incineration, the calorific value of the waste is an important feature. This value can be calculated[6] from the composition, as shown in table 2. Based on this calculation it can be expected that waste of the West Bank will have a calorific value of 11 MJ/kg, which is rather high. This high value is mainly caused by the high percentage of plastics.

Graph 4 shows average compositions of countries around the world according to their income.
According to this graph one could expect that plastics on the West Bank would account for no more than 11% which would lead to a calorific value below 10 MJ/kg. When in the future, prevention (for example a ban on plastic bags), separate collection and recycling will gain importance, the calorific value may further decrease to around 9 MJ/kg.

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[5] JICA/MoLG, Data book SWM of Joint Services Councils West Bank 2016, November 2017 and JSC-today publications of JICA and MoLG

[6] ISWA guidelines: Waste to Energy in Low and Middle Income Countries, 2013

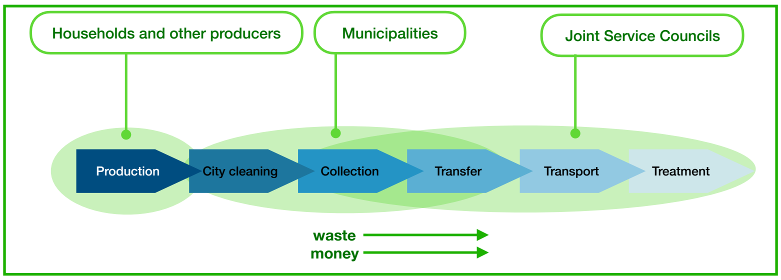
fraction	available	calorific value of fraction MJ/kg)	contribution (MJ/kg)
organic	50%	4	2,0
paper & cardboard	12,5%	16	2,0
plastics	14,6%	35	5,1
glass	1,9%	0	0,0
metals	2,4%	0	0,0
other materials	18,6%	11	2,0
Total			11,2

TABLE 2 CALCULATION OF CALORIFIC VALUE

GRAPH 4 AVERAGE WASTE COMPOSITION IN RELATION TO INCOME

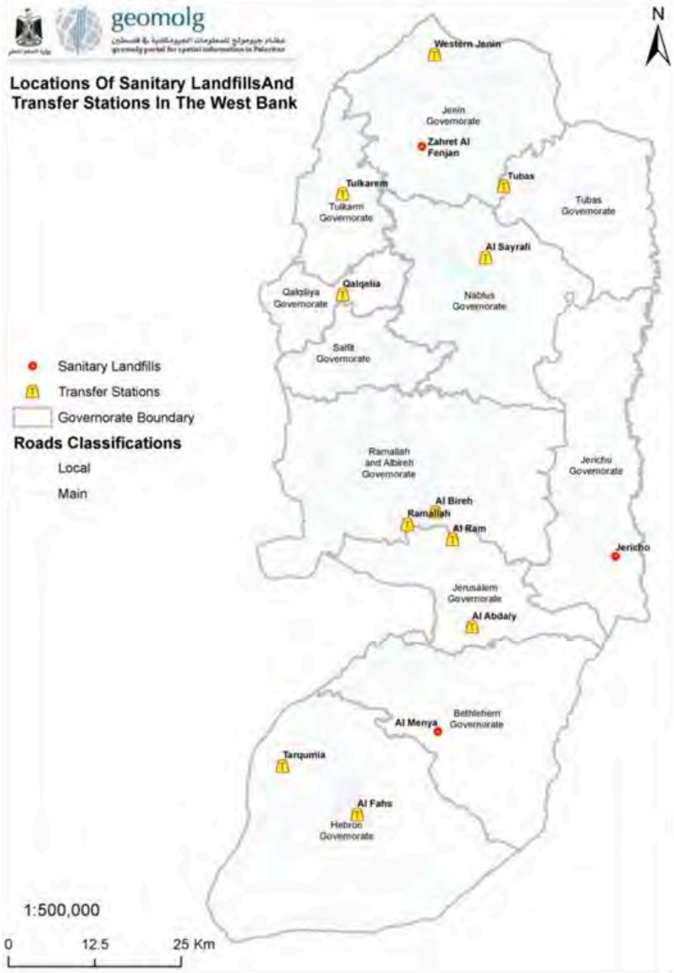
Organisation and value chain

In general, the waste is collected in dedicated collection vehicles and brought to a transfer site. On these sites the waste is bulked in large volume transport trucks in which it is brought to a landfill site. The costs of treatment and transfer are invoiced to the municipalities and added to the costs of collection and city cleaning. The municipalities decide to which extent these costs are translated into waste management fees that have to be payed by the households and other producers. Invoicing to the households is in most municipalities done by adding the fee to the electricity bill.



GRAPH 1. SCHEMATIC VALUE CHAIN OF SOLID WASTE MANAGEMENT

The present legal situation on the West Bank attributes the responsibility for waste management to the municipalities but they can delegate (part of) this responsibility to one of the thirteen Joint Service Councils. This task of the JSC's was established in the last 10 years and therefore falls under the responsibility of the Ministry of Local Government. The legal position is ruled by a 2016 bylaw. At this moment there is a hybrid situation with regard to the tasks of the JSC's. This situation is summarised in graph 2.



JSC	Collection	Transfer	Landfill
Hebron	+	-	-
Bethlehem	+	-	-
Jericho	+	-	+
Ramallah	+	+	-
N&NW Jerusalem	+	-	-
NE&SE Jerusalem	+	+	-
Salfit	+	-	-
Jenin	+	+	+
Nablus	+	+	-
Tubas	+	+	-
Qalqelia	+	+	-
Tulkarem	+	+	-
Hebron & Bethlehem	-	+	+

GRAPH 2 LOCATIONS OF TRANSFER STATIONS AND THE RESPONSIBILITIES OF THE JSC'S

The coverage with waste collection services by the JSC's ranges widely per municipality from 20 to 100% leading to an overall collection rate of 60-65% or 450.000 tons per year. The remaining 300.000 tons per year are being collected by Local Governmental Units (LGU's). Altogether some 2000 tons per day are reaching the two main landfill sites indicating that already a good percentage of over 90% of the households are serviced with collection services. These are the figures of 2016 provided by JICA/MoLG in their data book. The situation in 2018 will certainly show further improved figures. Earlier studies of GiZ[7] in 2014 suggested service coverages at that time of up to 90%. This feasibility study will assume a 100% coverage at this moment.

Apart from a few initiatives to start up separate collection of paper and cardboard, separate collection of household waste seems to be fully absent. With separate collection being an important prerequisite for substantially raising recycling, this absence is an obstacle that needs to be dealt with. Implementation of separate collection may take many years before paying off.

The JSC's operate 11 transfer stations, located across the West Bank as shown in graph 2. This network of transfer stations serves to disconnect collection of waste from long distance transport. It provides the municipalities with the possibility to empty their collection trucks within short distance of the collection routes. At the stations the waste is registered and transferred into bulk load trucks that make transport cheaper and that

[7] GiZ Sweepnet Country report on the Solid Waste Management in Occupied Palestinian Territories, April 2014

are better equipped to manoeuvre at the landfill sites. The importance of the network of transfer stations should not be under-estimated. It gives the region a strong instrument to manage waste streams and lower costs in a situation with many producers and only a few treatment facilities. This is especially true in the West Bank with the longer transportation times due to the difficult territorial situation.

The West Bank houses three sanitary landfills as shown in graph 2. The most important ones are Zahret al Fenjan in Jenin and Al Menya in Bethlehem. The landfill in Jericho has reached its maximum capacity and has no possibilities for extension. There is another landfill called Yatta, located in the governorate of Hebron. It was recently closed but could still play a role in energy production as it is equipped with landfill gas extraction accessories. A new landfill is planned near Ramallah but the plan was frozen because the needed land can't be made available as a result of the territorial restrictions imposed by Israel.

The landfill situation is in general described by the Palestinian authorities as "in crisis". The main topics of concern are mentioned to be: (i) lacking capacity, (ii) public opposition due to odour problems and (iii) poor leachate management. These problems are serious and, in fact, there is a fourth problem which is not mentioned: (iv) uncontrolled GHG emissions.

Nevertheless the situation may not be as dramatic as anticipated. The capacity problem at the two main landfills is not dramatic. The table below provides the data.

Landfill	Zahret al Fenjan, Jenin	Al Menya, Bethlehem	Total
Total surface in ownership (hectares)	24	26,5	50,5
In use for facilities (hectares)	3	3	6
Presently in use as landfill (hectares)	9	10	19
Average height of landfilled waste body (m)	40	20	60
Already landfilled on this area (mln tons)	2,8	1,5	4,3
Remaining capacity on this area (mln tons)	0,8	0,5	1,3
Potential capacity to be developed (mln tons)	4,8	2,7	7,5
Daily quantity delivered at landfill (tons)	1100	900	2000
Remaining lifespan (years)	**13,9**	**9,7**	**12,1**

TABLE 3 LANDFILL CAPACITIES

Some remarks can be made with regard to these capacities:

- The large potential capacity can only be used when properly prepared, designed and constructed. This needs time and has to be done without delay.
- The capacity of Zahret al Fenjan may be somewhat reduced because its steep slopes will need redesign. On the other hand degradation of waste will lead to further consolidation and to extra capacity.
- The capacity of Al Menya can be increased by deeper excavation of new cells and/or by raising its final height.
- Daily quantities of waste to be delivered at the sites will increase but this increase can be levelled by promoting recycling and WtE initiatives.

Capacity is not the only issue at the landfill sites. With regard to the subject of this feasibility study gas production and leachate treatment are equally important. Neither of the two landfill sites seems to be in control of these gas and leachate emissions. Nevertheless a solution is not difficult to find. At the heart of the problem seems to be the postponement of investments and costs related to adequate operations, application of a final, gas and rain-tight, landfill cover, and the catchment and treatment of this gas and

Abatement of odour problems

The people living around the Zahret al Fenian landfill are complaining about the odour nuisance. This nuisance is caused by a to large tipping zone, inadequate daily coverage, absence of covering the landfill with a gas tight cover and absence of treatment facilities for the 100 m^3 per day of leachate. Of course measures will need investments and higher operational expenses but these expenditures will be much lower than developing a new landfill site.

leachate. Most of these problems can be overcome when placed and dealt with in a proper agenda and budget.

There are only a few initiatives in the West Bank with regard to introducing recycling technologies. The two major landfills enabled the development of separation facilities on their sites. The facility at Zahret al Fenjan was initiated by the private company Al Kubra. It comprises the treatment of mixed municipal waste through a combination of sieving and conveyor belt hand picking in a production hall. Operations were stopped by Al Kubra due to negative financial performance. A similar operation was started at Al Menya and is still running.

Opportunities for recycling at landfills

The role of the existing separation facilities at the two landfills can be strengthened by using them for separating the wet, organic part of the waste from the dry residues. The organic fraction can then be degraded by composting. The product can't be used in agriculture but it is fit to replace the soil that is used for daily coverage. This will lead to a substantial reduction of landfilling of around 50%.

Another initiative worth mentioning is the digestion of organic waste and wastewater at the Al Jebrini food group in Hebron. The digestion produces biogas that is used for electricity production.

Most developing countries show interest in composting organic waste. It is a simple and cheap method to treat the organic contents of the waste and turn it into a valuable compost. Composting is a suitable treatment for organic market waste, agricultural waste and separately collected organic waste form households. Although the composition of the waste on the West Bank shows a good potential for composting, no initiatives in this field were spotted.

EQA, the Environmental Quality Agency is in charge of (a.o.) permitting, awareness, planning and monitoring whereas MoLG has taken the lead in setting up a national strategy on SWM[8]. This strategy is comprehensive and clear and touches all essential ingredients of SWM. The next step, operationalising this strategy into a masterplan, is still missing.

Masterplanning

Masterplanning is essential in order to acquire and improve insight in needed infrastructure and services, their scale and location, expected results, relations and integration, timing and needed resources. It will typically lead to scenario's enabling the authorities to base political decisions upon.

Costs, fees and affordability

The operational expenses and fee-ranges for waste management on the West Bank are summarised in table 4. These data are derived from the JICA databook. In general these data show that more than 50% of the money spent by municipalities on SWM, is used for collection of the waste.

collection	50-150	NIS per ton	12-35	€/ton
transfer when applicable	10-60	NIS per ton	2,50-14	€/ton
sanitary landfill	30-33	NIS/ton	7-8	€/ton
total costs	60-250	NIS/ton	14-60	€/ton
SWM fee	12-30	NIS/hh.month	2,80-7	€/hh.month

TABLE 4 EXPENSES(OPERATIONAL) AND FEES FOR WASTE MANAGEMENT.

When taking into account an average household size of 4,8 persons and a waste production of 0,75 kg/person.day, an average family produces 1,3 tons of waste per year. Applying this production to the above operational expenses and fees leads to the conclusion that fees, established and imposed by the municipalities, must be able to cover all operational costs. In practice, the rate of actual fee-payments will be (much) lower than 100%. For example, Ramallah reported fee payments to be around 65%, leaving the municipality with a deficit of 35% to be paid from the municipal budget.

[8] National strategy for solid waste management in Palestine 2017-2022

Assuming an average monthly family income of NIS 2500 it can be concluded that imposed fees consume around 1% of this family budget. This percentage aligns, in general, with international standards on the affordability of SWM fees.

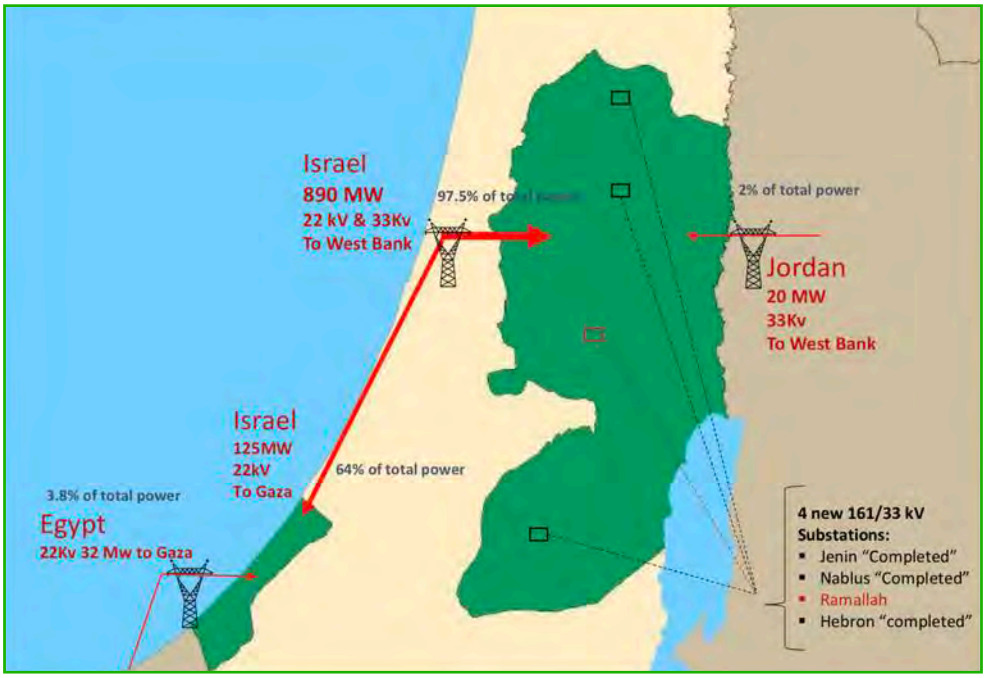
One of the most important financial aspects for this feasibility study is the 30-33 NIS (€ 7-8) per ton that is now being payed for landfill treatment. This price will serve as a reference level for treatment alternatives like recycling.

2.3 Energy

Consumption, production and transmission

The electricity consumption in the West Bank in 2017 is estimated at around 4500 GWh with a peak demand at 930 MW. Although the currently available capacity is no more than 830 MW, the West Bank enjoys an almost 24 hours of undisturbed power supply. E-consumption is however growing at a little under 3,5% per year, meaning an extra need for 150 GWh each year.

Some 98% of all electricity on the West Bank is supplied by the Israeli Electric Company IEC over the 161 kV Israeli owned high voltage grid, connecting to the Palestinian owned low and middle 11, 22 and 33 kV grid . The present system with hundreds of small connections is strengthened at this moment by adding 4 new substations connecting the 161 kV grid to the 33 kV grid (see graph 4). Jenin is completed and in operation, Nablus and Hebron are completed but not yet in operation. The purpose of the substations is that PETL (the Palestinian Energy Transmission Limited) can take over the control of all connection points.



GRAPH 3. HIGH VOLTAGE GRID FEED-IN

The domestic production of electricity is still very low and limited to around 22 MW of photovoltaic power. PV is nevertheless very promising due to the favourable circumstances mentioned under paragraph 2.1. Other advantages of PV are its scalability, its limited feed-in capacity needs, the absent need for cooling capacity and the fast decrease in needed investments and price per kWh. On the negative side are of course the need for backup and/or storage capacity.

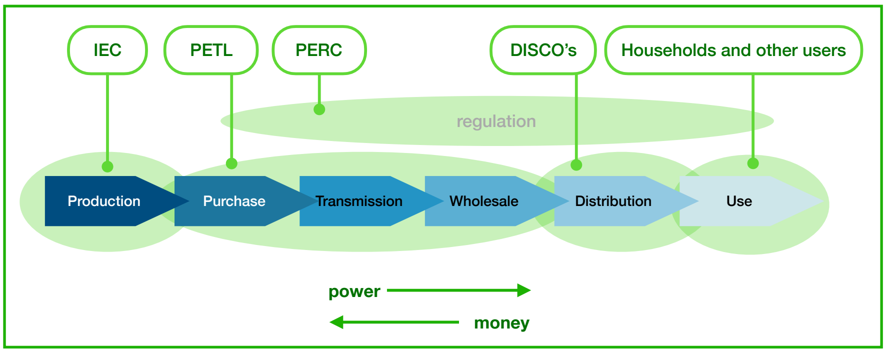
This favourable situation is reflected in the vast number of projects under development and construction. The largest project at this moment is the Bani Na'im project in Hebron with a capacity of 30 MW on 6 ha, producing a yearly 50 GWh equalling 1% of Palestines yearly consumption.

Palestine targets at substantially increasing the production of renewable energy towards130 MW in 2020 and 500 MW in area's A, B and C together in 2030. Also here PV is expected to deliver a substantial 80% of these targets whereas 10% is to be covered by wind and 10% by biomass and biogas. The latter percentage is the category where Waste-to-Energy fits in. It represents 10-15 MW to be delivered in 2020.

Organisation and value chain

The organisation of the Palestinian energy management has been substantially upgraded in the last years. The pursued system with main public authorities in this field is summarised in graph 3:

- PENRA, the Palestinian Energy and Natural Resources Agency acting as the ministry under the direct authority of the prime minister.
- PERC, the Palestinian Energy Regulatory Council in charge of pricing and regulations
- PETL, the Palestinian Energy Transmission Limited, in charge of purchase, wholesale and grid operations.



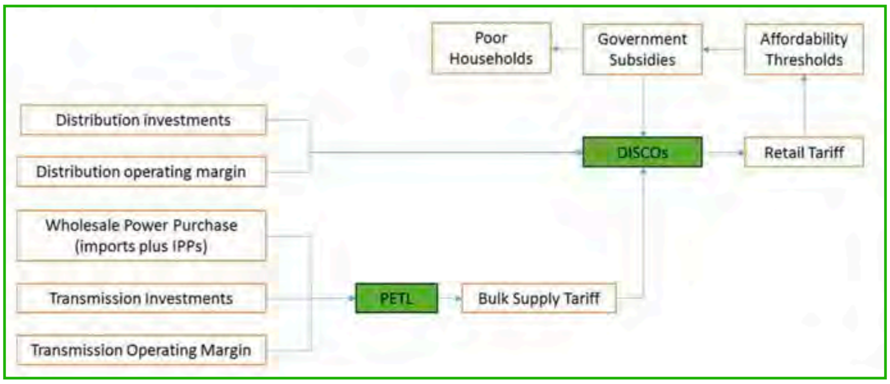
GRAPH 4. SCHEMATIC VALUE CHAIN OF ELECTRICITY SUPPLIES

Sales to households and other users on the West Bank is done by 5 private distribution companies (Disco's) servicing some 440.000 customers. Still many municipalities today directly purchase from IEC.

Relevant with regard to this feasibility study is that actual electricity production is a privileged activity for private actors only. This means that public actors, as the municipalities and JSC's, are allowed to perform all waste treatment operations accept for the last step; turning steam or gas into electricity.

Costs and prices

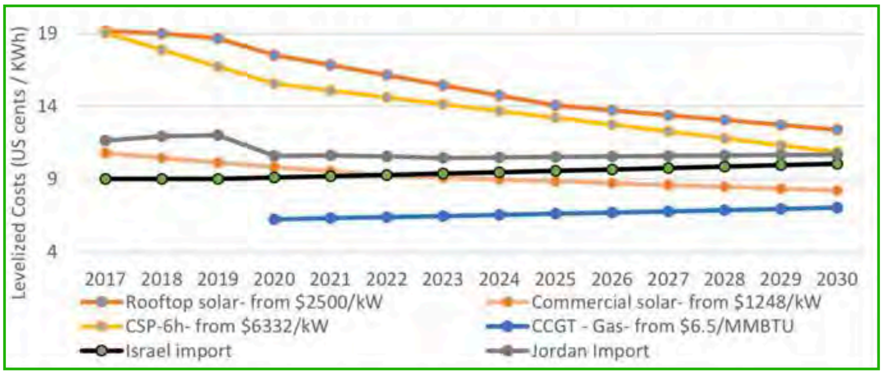
Cashflows in the pursued Palestinian electricity sector can be schematised as done in graph 4[9].



GRAPH 5. CASHFLOWS RELATED TO THE PALESTINIAN ENERGY SECTOR.

An overview of the levelised costs of electricity on the West Bank is summarised in the graph below.

[9] Securing energy for development in West Bank and Gaza, World Bank Group, June 30, 2017



GRAPH 6. LEVELISED COSTS OF MOST RELEVANT E-PRODUCTIONS

This summary shows that the dominant feed in of Israeli imported electricity is gradually going up to a price of 10 $cents per kWh. Any new feed-in alternative will have to, at least, match this price. But what's more important is the interesting decrease of commercial solar prices which are expected to go below the price of Israeli imports already in 2022. This extrapolation will be the reference line for new entries. Alternatives will need to be able show a levelised costs of electricity of no more than 7 or 8 $cents, unless governmental policies accept a higher price for electricity from waste.

The World Bank holds high expectations of rooftop and utility scale PV electricity for the West Bank; mainly due to its low capex of $1300 per kW or €750 of capital expenses to produce 1 MWh/year. Biomass based alternatives are thought to be more capital-intensive, as illustrated in graph 6.

GRAPH 7. CAPITAL COSTS OF RENEWABLE ENERGY ALTERNATIVES.

Table 5 provides an overview of retail turnovers for all DISCO's. In 2015 22% of all power purchased for the West Bank was lost or never billed because of technical losses and illegal connections. A total sum of 1,5 bln NIS was billed to consumers of which 89% was collected.

	GEDCO	Total West Bank	JDECO	NEDCO	HEPCO	SELCO	TEDCO
Scale							
Customers	231,500	436,389	256,314	90,265	45,660	25,650	18,500
Purchased Electricity (mil NIS)	795	1,398	871	250	164	71	42
Billed Electricity (mil NIS)	518	1,509	949	245	193	76	46
Net Annual Income/loss (mil NIS)	n.a	-76	-82	9	9	-15	3
Performance							
Losses-Technical and non-technical (%)	26%	22%	24%	17%	20%	28%	16%
Collection ratio (%)	65%	89%	91%	98%	81%	71%	76%
O&M as percentage purchased electricity (%)	8%	17%	22%	5%	10%	21%	17%

TABLE 5. DISCO FINANCIALS FOR 2015

2.4 Implications for this study

The overview in this Chapter 2 provides a number of implications for this feasibility study. The most important are summarised below. They will serve as input for the calculations in this study.

- Land availability is low and is restricted by the complex political situation.
- There is no water body available that can be used to deliver cooling water. As a result a choice has to be made for dry cooling resulting in a 1% reduced electricity efficiency and 2% higher investments.
- There is no demand for the use of co-generated heat indicating an absent viability for CHP
- The West Bank is producing a quantity of 720.000 tons/year of municipal solid waste and this quantity will grow in 15 years towards 1.200.000 tons/year in 2032.
- It is reasonable to assume a near 100% coverage of waste collection with all collected waste reaching the two main landfills.
- The waste contains 50% of organics and the calculated calorific value is expected to be 9 MJ/kg.
- Waste treatment options will be in the hands of the JSC's with the MoLG able to safeguard adequate scales of economy.
- The transfer stations already play a significant role in reducing transport costs by handling 65% of all collected waste. For this reason this study assumes that introducing a new WtE or any other waste treatment facility will have only minor effects on transport costs and transport emissions, provided the logistical system will be managed with a focus on lowest costs and emissions.
- Landfill capacity seems to be sufficient for the next 10 years.
- The price reference level for waste treatment (gate fee) will be 35 NIS or €8,50 per ton.
- The energy policies are in the hands of Penra. Their expectations with regard to energy derived from waste are a power production capacity equalling 10-15 MW in 2020.
- At this moment there is no professional workforce available for the operation of complex energy production plants.
- Single feed-in capacities of electricity to the grid can not exceed 10 MW at this moment.
- The price reference level for feeding in electricity to the grid lies at 7-8 $cents per kWh.

3. Options for this study

3.1 Selection of options

As per the ToR of this study, the report will describe at least the following options:

1. enhanced landfill gas extraction from landfills followed by electricity production
2. direct incineration of waste followed by electricity production

A study on the WtE options for the West Bank would not be complete when not reviewing the production of methane through bio-treatment in a processing facility. Therefore the following option is added.

3. anaerobic digestion of organic waste followed by using the gas for electricity production

There seems to be a firm commitment of the Palestine authorities towards producing energy from waste. This commitment may be logical when looking at the energy challenges the West Bank is faced with. Nevertheless it may be wise to prevent an “energy-only” bias. For this reason it is thought helpful to assess the situation in a slightly broader perspective by adding at least one other, non-energy, option for waste treatment. For this reason a fourth option is added.

4. composting of organic waste into a compost fit for agricultural use.

Of course there are a number of other alternatives that would be interesting to assess in the Palestine situation. Below a few of them are listed and the reasons for not assessing them as options in this study are given.

- Gasification. This technology treats waste at very high temperatures (above 1300 ^{0}C) and restricted oxygen levels. It results in a syngas (mixture of CO and H_2) that can be used for energy production or chemical synthesis. Due to its reduced input of air the exhaust gas has a smaller volume making it easier and cheaper to treat. It also produces an inert glass-slag that can be used as an aggregate in, for example, road construction. A number of technologies are available. All of them are very complex and expensive. Gasification is a proven technology for homogeneous, well defined, small particle inputs with a very narrow bandwidth of its specifications, such as coal. Other, more complex, inputs are making this technology extremely difficult to design and to operate under industrial conditions. Waste can be thought of as the most inhomogeneous and complex input, making gasification technologically impossible to apply.
- Pyrolysis. A technology that heats up its input to more moderate temperatures (300-900 ^{0}C) but in this case with the exclusion of oxygen. It produces a mixture of gases, liquids, tars, chars and inerts. Also here the output can be used for the production of energy and chemicals. Notwithstanding its more moderate temperatures, also here the conclusion must be that the technology is not fit for mixed waste. Although claimed otherwise, there are no proven processes and installations operating on mixed waste at an industrial scale.
- High efficiency incineration. A regular energy efficiency, with regard to the production of electricity, is 20%. There are technological options to raise this efficiency to 30%. These options are however not state-of-art and it would be somehow opportunistic to consider this hightech option for the West Bank.
- Biocell landfilling. This technology considers a landfill to be a bioreactor. It uses a specific cell in a landfill and fills it with waste with a high content of organics. The rationale for this technology is that investments and operations for gas extraction can be more dedicated for smaller cells with higher landfill gas outputs. Although one could expect feasible operations on the gas production side, managing an organics-only cell is complicated and not yet proven.

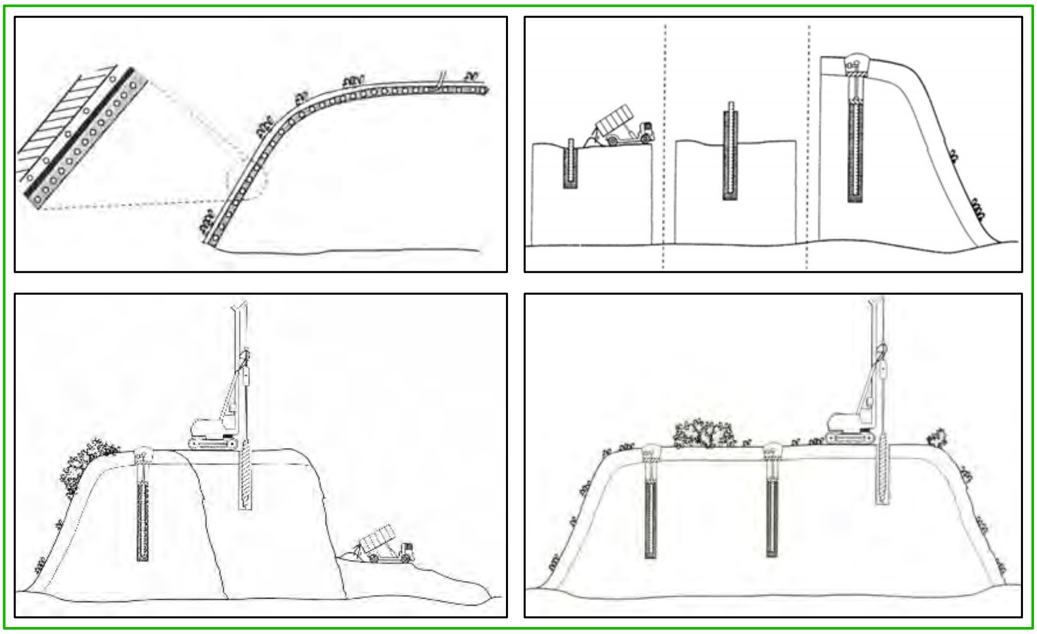
3.2 Description of options

This paragraph describes the four options in more detail and places them in the West Bank context.

Option 1 Enhanced landfill gas extraction.

Landfills produce gas and without measured to capture the methane it will be emitted into the air causing odour nuisances in the surrounding areas and fire-risks. Moreover methane is an important cause of global warming as the emission of 1 ton of CH_4 equals an emission of 21 tons of CO_2.

The extraction of the gas should be started as soon as possible after starting up constructing the landfill body. This is illustrated in the graph below[10]. It starts with building up the waste body vertically to the designed end-height as fast as possible. As soon as a substantial final surface is available, extraction wells should be brought in and application of the final, water and gas-tight, cover of clay and/or HDPE starts.



GRAPH 8. PROCEEDINGS OF A LANDFILL GAS EXTRACTION SYSTEM

Capturing and treating landfill gas is a crucial ingredient of sanitary landfilling. It is obligatory even when not considering the use of extracted gas for energy production. In that case the extracted gas should be flared, resulting in a reduction of GHG emissions with a factor 20. For this reason, the investments and operational costs of the landfill coverage, gas extraction system and flare should not be part of the business case that evaluates the production of electricity from landfill gas. That business case should start at the point where the gas is delivered to the boundary limits of the electricity production unit.

After starting up landfill operations, the gas production will start gradually as shown in an example in graph 9. It is not possible to recover and use all produced gas. It all depends on the actual design and operation of a specific landfill site. In the first stage of operation methane emissions are inevitable. Capping the landfill is of utmost importance and in a situation with 100% capping, a good redundancy in gas wells and maintaining overall under-pressure, a capture of 80% of the gas may be feasible.

The ability to use the gas for electricity production is influenced by the volume and CH_4 contents. If not sufficient, flaring is the only option. Electricity production from landfill gas typically will include the removal of

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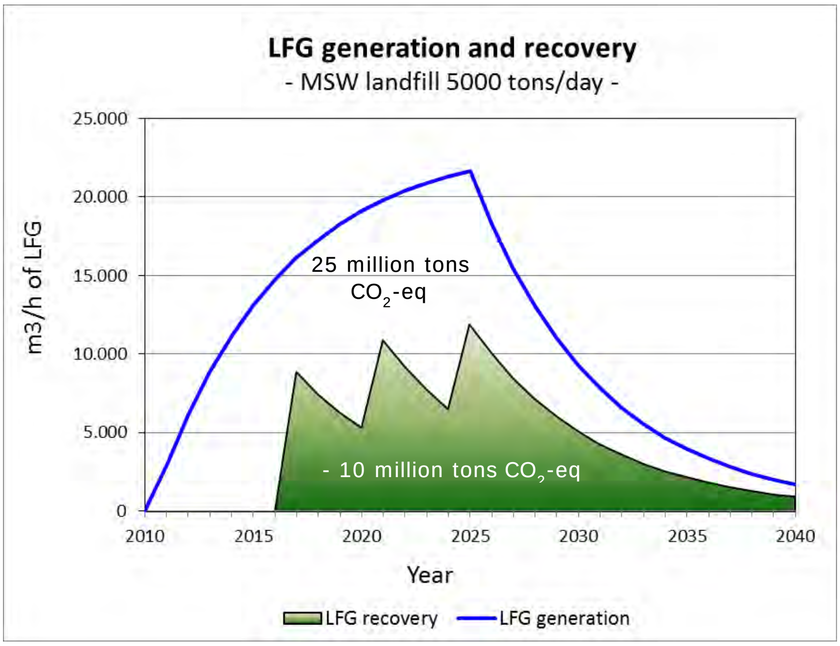
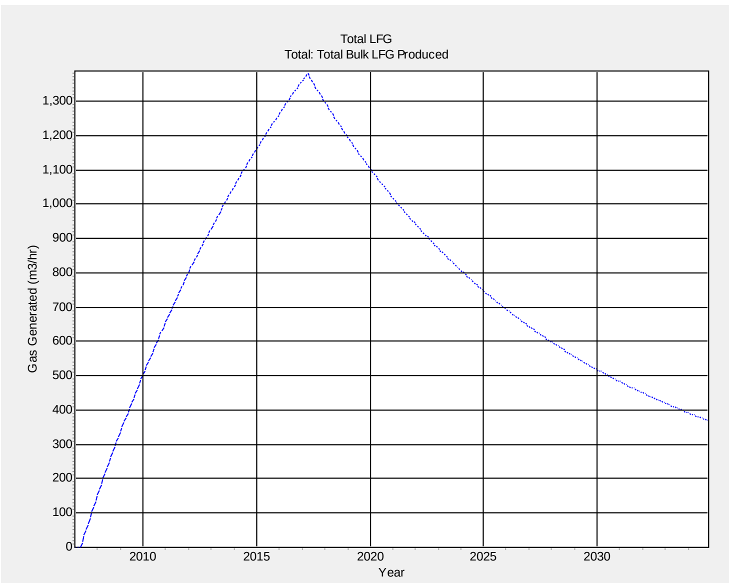
[10] Illustrations provided by N.V. Afvalzorg, Dutch public landfill company, 2018

excess water and condensate, a booster producing suction capacity to enforce gas extraction and regulation and gas-engines supplied with generator-sets. Synchronisation, transformation and additional high voltage transport to connect to the high voltage grid completes the set up.



GRAPH 9. TYPICAL GAS PRODUCTION AND RECOVERY OF A 5000 TONS/DAY LANDFILL

In 2013 a feasibility report was delivered by Integrated Skills, evaluating the potential and costs of electricity from gas at the Zahret al Fenjan landfill site in Jenin[11]. The report is comprehensive and covers all relevant aspects of the opportunities at this site. It assumes that with the application of a final capping liner a collectable volume gas of around 1200 m^3/hour can be collected in 2017 gradually decreasing to a situation in 2035 where gas collection will not suffice to maintain electricity production. The extracted gas will in that case be flared or treated by bio-filtering.



GRAPH 10. GAS PRODUCTION AT THE ZAHRET AL FENJAN LANDFILL

[11] "Consulting services for electricity generation from MSW, Jenin", Integrated skills, IDB report, October 2013

For this study we will assume that landfilling will be continued after completion of the present cells and will be continued for at least 10 more years. For this situation we can assume a strong potential for at least 10 more years with the decrease starting in 2030. From 2020 until 2030 it can be assumed that the new landfill will have a similar gas production as the old one and for this reason both productions can be added as shown in table 6. All these assumptions are only applicable in a case of optimised capping and optimal management of both the old and new landfill cells with a focus on starting up and optimising gas production.

Cooperation and integration

Cooperation between the landfill sites can be very advantageous when it comes to sharing and exchanging gas-engines and gen-sets in order to install optimal configurations as much as possible.
Landfills have a potential for installing PV capacity on their slopes. In that case integration of grid connections in to one system can reduce investments and costs considerably.

A similar projection of gas production and collection was provided by Al Menya[12]. The site has already started up installing gas extraction wells and is now preparing for its collection and treatment. The projection for this site assumes a recovery of 65%, supposedly based on delayed application, or even absence of a top cover. As stated above, the application of a top cover is priority number one, no matter whether the gas is reused or flared. For this reason these projections were translated to 80% recovery for capped landfills giving the gas collection volumes as stated in table 6.

Gas collection in m^3/hr	Zahret al Fenjan, Jenin	Al Menya, Bethlehem	Total gas collection	Potential for electricity production (kW)
gas production in 2018	1200	500	1700	4072
gas production in 2020	1300	700	2000	4790
gas production in 2025	1600	1300	2900	6946
gas production in 2030	1600	1700	3300	7904
gas production in 2035	1300	2000	3300	7904
gas production in 2040	800	1700	2500	5988
gas production in 2045	400	1500	1900	4551

TABLE 6. GAS COLLECTION PROJECTIONS AND ELECTRICITY POTENTIAL FOR THE TWO MAJOR LANDFILL SITES

This table illustrates the projection of potential electricity production, showing 4 to 8 MW at the two major landfill sites of the West Bank. The Yatta and Jericho landfills are not included in this table as they are not in the focus of this study. Yatta is reportedly producing 900 m^3/hr at the moment; the production potential of Jericho is unknown so far. The potential can't be "harvested" to its full extent because of two reasons: (i) flaring is always needed to some extend because investments in gas-engines and gen-sets are performed by installing multiple sets with distinct capacities of for example 0,5 or 1,0 MW_e and (ii) installed sets need maintenance leading to operational availability of around 85%.

Typical data on capex and opex can be derived from the businesscase provided by Integrated Skills. For the purpose of this feasibility study the following financial inputs will be used.

capex and opex	costs
landfill capping (€/ha)	350.000
investment in gas-collection and e-production (€/ha of capped landfill)	200.000
opex per landfill (€/year)	300.000

TABLE 7. TYPICAL CAPEX AND OPEX FOR CAPPING, COLLECTION AND E-PRODUCTION

12 Projections provided by personal email through Majed Al-Sari, August 2018

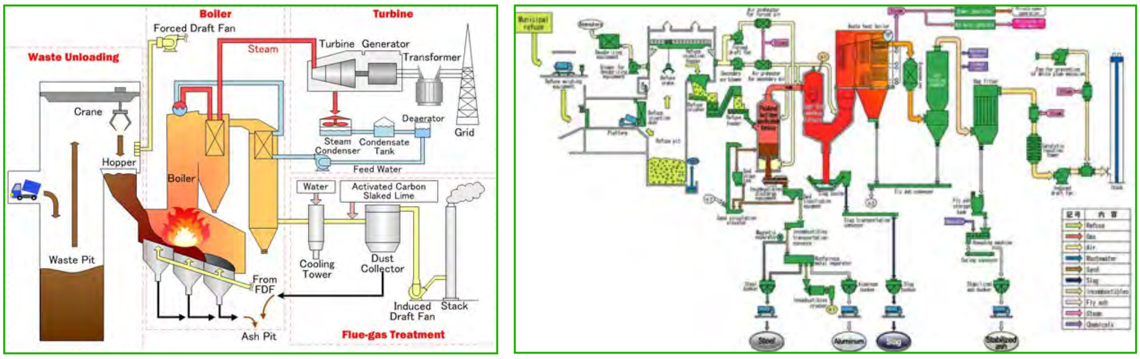
Gas extraction from landfills has substantial effects with regard to reducing GHG emissions. The effect can be calculated for the two main landfills by taking their emissions for a situation with and without capping and with and without electrification of the gas. This calculation is summarised in annex 2. The effect of these calculations can be summarised as follows:

- Collection of the gas and flaring of the collected gas leads to a reduction of GHG of 68% when compared to a situation with absence of preventive measures.
- Turning the collected gas into electricity will lead to an additional reduction of 3%.

Extraction of landfill gas for energy purposes has no effect on the use of landfill capacity

Option 2 Direct incineration

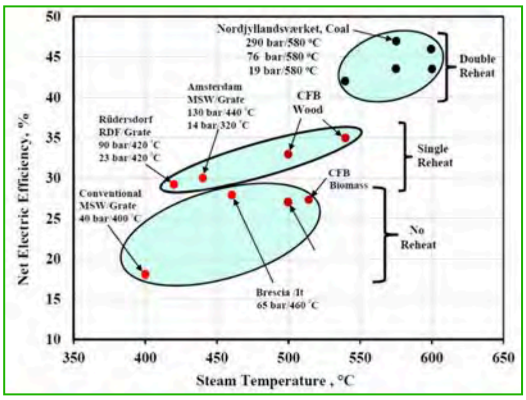
One of the most common ways to extract the calorific value of waste is direct incineration, combined with steam production and electricity generation. Western Europe was leading the way in this field but China is taking over fast.The technology is complex, expensive and only feasible at a large scale. In general the main technologies are moving grate and circulating fluid bed with process schemes as presented in graph 12.



GRAPH 12. MOVING GRATE AND CIRCULATING FLUID BED TECHNOLOGY

The flue gas heats up the steam but after this stage the gas needs extensive cleaning before being fit for emitting. Gas cleaning accounts for a major part of the investments.

Conventional moving grate installations range around 18% in electric efficiency as shown in graph 13[13]. Recent improvements in incinerator operations have raised this efficiency to above 20% but this is in situations with availability of cooling water and a hi-tech knowledge environment. In the West Bank situation this is not the case and for this reason overall efficiency will be no higher than 20%.



GRAPH 13. ELECTRICAL EFFICIENCY OF WASTE INCINERATION

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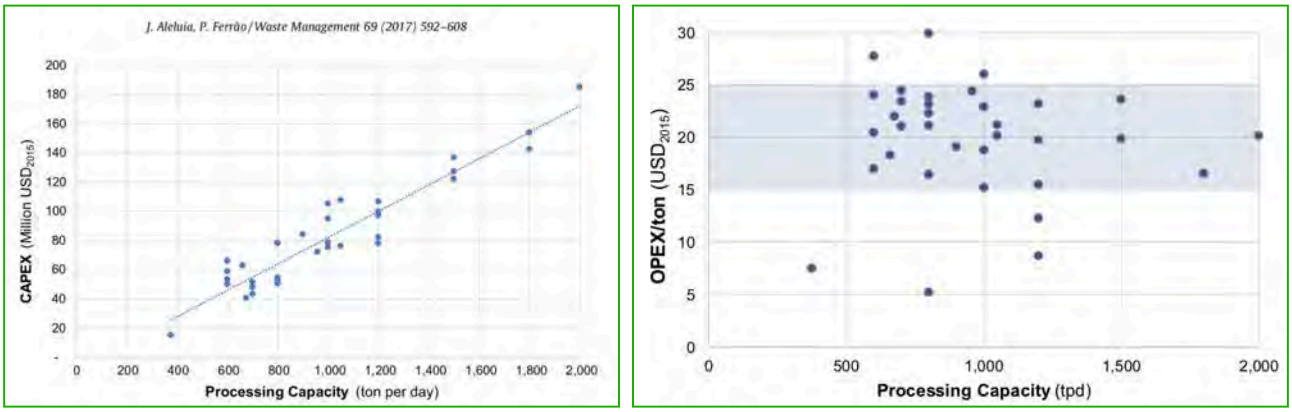
13 World energy resources, Waste to Energy 2016, World energy council

Waste incineration will lead to high investments and operational costs. Higher capacities will show an economy of scale as presented in a recent study[14] and shown in graph 14. For this feasibility an adequate capacity needs to be set in order to be able to perform the assessment. This capacity will be fixed at 1.000 tons per day (300.000 tons/year), representing 40% of the West Bank waste production. A higher capacity may seem attractive but it may not be wise to make a larger part of the region's waste management dependent on only one treatment facility. The other consideration is that sound waste management policies leave room for future developments on reducing, reusing and recycling waste.



GRAPH 14. CAPEX AND OPEX OF DIRECT INCINERATION IN ASIA.

Graph 14 is related to Asian installations and most of them are constructed by Chinese contractors. They typically lead to an investment of $230 per installed year-ton. European installations show substantially higher investments with an average of almost $900 per installed year-ton. This huge price difference will of course reflect the performance and expected lifetime of the installations.

Just recently Ethiopia inaugurated the first incineration plant of Africa; the so-called Reppie project serving the city of Addis Abeba with a capacity of 420.000 tons per year and an investment of $130 mln. It was build by a consortium of UK and Chinese contractors according to EU emission standards. With this facility's investment as a reference and bearing in mind the effects of economy of scale, the absence of cooling water and needed investments in a connection to the high voltage grid, the projected 1.000 tons per day facility for the West Bank would lead to an investment of around € 110 mln. This investment will be used in this study. Operational expenses will be held at €20 per ton and €1 mln per year will be added for needed major replacements.

Incineration produces CO_2 but on the other hand it replaces CO_2 emissions of other electricity productions. The below figures are derived from [15] .

Life cycle CO_2 emission	g/kWh$_e$
Coal	987
Gas	446
MSW	367

TABLE 8. CO2 EMISSIONS FROM E-PRODUCTION WITH DIFFERENT FUELS

Using these data would lead to a net reduction of 79 grams of CO_2 per kWh when compared to producing electricity from gas. If incineration would be compared to the present situation in the West Bank of open landfilling, also the prevention of landfill-gas from this present situation should be added as a positive effect.

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14 Assessing the costs of municipal solid waste treatment technologies in developing Asian countries, Waste Management 69 (2017) 592-608, João Aleluia and Paulo Ferrão

15 ISWA guidelines: Waste to Energy in low and middle income countries, ISWA report of August 2013

Waste incineration produces bottom and fly-ashes. Around 75% (m/m) of the input will be eliminated. The residues of 25% could partly be reused as construction material in case their leaching behaviour is sufficiently controlled. In this feasibility study it is assumed that the ashes will be landfilled. This leads to an overall reduction of the use of landfill capacity of 75% related to the input of 300.000 tons per year.

Waste incineration needs extensive preparations for design, contracting and permitting. Including the time needed for construction a period of at least 5 years is needed from the moment of deciding to start the process until finishing the commissioning period.

Option 3 Anaerobic digestion

Anaerobic digestion is a biological process in which oxygen is excluded providing favourable circumstances for the bacteria to turn organics into methane. In its essence the biological processes are the same as in landfill gas production, only this time it is done under well controlled industrial conditions. The remaining sludge (digestate) is then aerobically turned into compost, fit for agricultural use.

For this study it is assumed that the input will consist of separately collected organic municipal waste. This makes the process less complex and it will safeguard that the compost can be put on the market. This connection to the implementation of separate collection may however lead to a period of 5 years needed for implementation.

One ton of organic waste produces 70 m^3 of biogas with 60% of methane. The biogas can be turned into electricity in the same way as landfill gas. Next to this, one ton of input produces 0,4 tons of compost.

Typical investments in modern anaerobic digestion installations can be calculated using €5-800 per installed ton per year. The above mentioned literature on Asian installations mentions investments of around €100 but because of lack of information on the performance of these installations this indication will be considered to low and an investment of €400 per installed ton per year will be used. When taking an installation with a year capacity of 50.000 tons, the investments will be € 20 mln and operational expenses around €20 per ton. Post treatment of the digestate by composting is not included in these figures. Costs for this additional step are highly dependant on the technology to be used. Simple windrow composting is very cheap (see next option). For this feasibility study an extra investment of € 3 mln will be included to treat the remaining 30.000 ton per year. Next to that extra operational expenses of € 7 per ton op organic waste input (or €10 per ton of digestate) will be included. Anaerobic digestion needs separate collection of organic waste. The extra costs of separate collection are fixed at €10 per ton of collected waste being € 20 per ton if attributed to separately collected organic waste only. Overall this leads to investments of €23 mln and opex of €47 per ton.

Anaerobic digestion of the organic fraction of MSW leads to less emissions of GHG and to a reduction of the use of landfill capacity.

Option 4. Composting

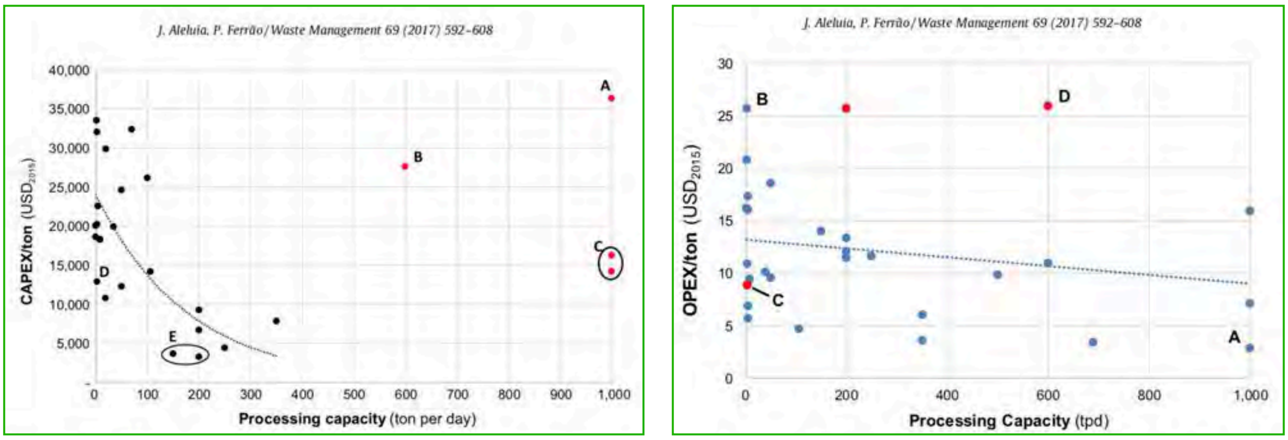
Composting is a simple technology, reducing the waste volume and mass by biological processes in an oxygen rich environment. The produced compost can be used in agriculture.

There are a number of technology alternatives, ranging from windrow composting in the open air, to controlled indoor composting in vessels, halls or tunnels.

Comparison of Composting Technologies

	Investment	Maintenance	Space	Time	Labor
Windrow Composting	•	•	•••••	•••	•••••
Passively Aerated W.	••	••	•••••	•••	••
Forced Aerated W.	••••	••••	••••	•	••
In-Vessel	•••••	•••••	•••	•	••
Bin Composting	•••	••	•••	•••••	••

A typical capacity of 50.000 tons per year would need an investment of around € 2 mln in its simplest form and opex of around €10 per ton (see graph 15). For safety reasons investments will be raised to €3 mln, anticipating a need for some kind of forced aeration and control of humidity.



GRAPH 15. CAPEX AND OPEX IN ASIAN COMPOSTING FACILITIES.

Also here the extra costs of separate collection of €10 per ton have to be included. Produced compost may have a good market value on the West Bank but because this value is unknown it is assumed that compost is brought to the market at zero value. Overall, investments of €4 mln and opex of €10 per ton can be expected.

Composting reduces the need for landfill capacity and reduces the emission of GHG on the landfills but, unlike the first three options, there will be no energy production.

When composting is connected to separate collection, the implementation period will be similar to anaerobic digestion. There is however an option that may make composting already applicable within one year. In this case composting will be used as a pre-treatment step before landfilling. the incoming waste will be separated in a wet and a dry fraction by using drum-sieving. The wet organic fraction will stabilised by composting, thus preventing the production of methane. The product will be usable for daily coverage which will lead to a reduced use of landfill capacity.

4. Assessment

4.1 Method

The assessment will be performed using a multi-criteria analyses. The criteria to be used are:

- **Technical**. With relevant aspects:
  - Complexity. Qualitative. Increasing complexity is considered negative in general
  - Flexibility. Qualitative. Flexibility means that the option can be adopted more easily to changing circumstances.
  - Needed scale. Quantitative. A higher needed minimum scale leaves less room to alternatives.
  - Needed knowledge, experience and technological environment. Qualitative. Higher levels may lead to lower feasibility when these factors are not available.
  - Required connections to network. Quantitative. A larger needed connection could make the technology not viable under present Palestine circumstances.
- **Financial**. With relevant aspects:
  - Needed capital. Quantitative. In order to make the assessment comparable this aspect will be calculated for a case in which the option is maximally implemented on the West Bank
  - Needed gate fee. Quantitative. This aspect will be evaluated by using a fixed energy price of €0,07/kWh to calculate the needed gate fee for achieving total cumulative cashflows of zero in 10 years.
- **Landfill consequences**. With relevant aspects:
  - Reduction of use of landfill capacity. Quantitative. The assessment will calculate the effect on the use of landfill capacity as a percentage of the waste treated in the options.
- **Environmental/social**. With relevant aspects:
  - Reduction of GHG emissions. Quantitative. The assessment will calculate the positive effect per year on the reduction of GHG emissions when all suited waste would be treated through the option. This will be compared to the present situation in which the waste at the landfills stays uncovered.
  - Waste hierarchy effects. Quantitative. This aspect will be evaluate by providing the production of goods, other than energy, through the options.
  - Public acceptance. Quantitative. This aspect will provide an indication of expected public acceptance in the neighbourhood of (future) sites where the activities will take place.
- **Energy**. With relevant aspects:
  - Production potential. Quantitative. The aspect will be made quantitative by calculating the total potential energy production when all suited waste would be treated through the option.
  - LCOE. Quantitative. The Levelised cost of electricity will be calculated by applying all costs and all electricity over a 15 year period with a discounting ratio of 8%.
- **Other relevant aspects**
  - Planning. Qualitative. The time needed for implementation will be provided.
  - Effect on institutions. Qualitative. Any effects on present organisational settings will be evaluated.
  - Risks. Qualitative. Any other risks, not mentioned above, will be assessed here.

The financial aspects will be evaluated by using a simple cashflow analyses over a 15 year period after start up of operations with full financing at an interest rate of 8%. This analyses is only fit for comparison of the options in a more quantitative manner. Defining an adequate and usable businesscase would require a more dedicated analyses of all investments and financial parameters.

An assessment like this will enable the use of multi criteria analyses needed for comparing the options. It may however look somehow clinical and abstracted from day-to-day felt needs for answers and solutions in an urgent setting. For this reason the assessment will be completed by considering in paragraph 4.3 some questions and answers that could lead to scenarios that may be helpful for decision-making.

4.2 Elaboration of assessment

Assessment option 1. Enhanced landfill gas extraction.

Landfill gas extraction without using the gas for electricity production is considered to be the basic option. The gas will be flared, turning the methane into carbon-dioxide. It will lead to a reduction of CO_2 emissions of 87.000 tons per year for the West Bank as a whole. Option 1 is considered to extend this base case with electricity production instead of flaring and it will raise the emission reduction to 90.000 tons/year. The actual situation will not be this ideal as there will always be parts of the landfills that will be uncovered and for this reason the assessment will be based on a reduction of 80.000 tons/year

The table below summarises the assessment of this option.

Categorie	Aspects	Score	Explanation
Technical	Complexity	low	Simple proven technology
	Flexibility	very high	Using the collected gas for other purposes is easy
	Minimum scale	n.a.	Not applicable. Can be applied at all scales. Scale is dictated by size of landfill.
	Knowledge c.a.	low	Knowledge and experience readily available or easily trainable.
	Connections	< 10 MW	Needed connection can be applied to existing network.
Financial	Capital needed	€ 30 mln	For both major landfills in the West Bank. Including capital needed for capping
	Gatefee	€ 0,50 per ton	Extra gatefee needed to achieve zero cumulative cashflow in 15 years
Landfill	Prevention use	0%	No positive effect on reduction of landfill capacity.
Environment/social	GHG emission	reduction of 80.000 tons of CO_2 per year	If all waste would be landfilled and all landfill gas would be collected and turned into electricity it would mean that an emission of 3300 m^3 of gas per hour would be dealt with. The reduction is the calculated prevention of CO_2 per year using the equations of graph 11.
	Waste hierarchy effect	no effect	No positive effect on prevention, recycling etc.
	Public acceptance	high	Strong effect on reducing the odour nuisance of population in vicinity of landfill.
Energy	Production potential	40 GWH/yr	For both major landfills in the West Bank. Around 1% of West Bank consumption.
	LCOE	€ 69/MWh	At a discounting rate of 8%.
Other	Planning	2 years	Mostly time needed for capping
	Institutions	none	no institutional effects
	Risks	none	no risks

TABLE 9. SUMMARY OF ASSESSMENT FOR ENHANCED LANDFILL GAS EXTRACTION

From this table it can be concluded that landfill gas extraction has the potential to produce 40 GWH of electricity per year at an interesting LCOE. The LCOE includes the costs of capping the landfill. It could very well be argued that capping costs should not be included in which case the LCOE would drop to around €50/MWh.

If a fixed feed-in price of 7 eurocents per kWh is applied it can be concluded that only € 0,50 per ton of extra gatefee is needed to achieve zero cumulative cashflow after 15 years.

Notwithstanding these already positive results it should be concluded that capping the landfills and using the gas are unavoidable decisions considering the enormous reduction of 80.000 tons of carbondioxide that can be achieved.

Implementing this option would lead to a substantial decrease of odour nuisance caused by the landfills and will thus lead to increased public acceptance.

The separate businesscases for both landfills can be found in Annex 3.

Assessment option 2. Direct incineration.

The table below summarises the assessment of this option.

Categorie	Aspects	Score	Explanation
Technical	Complexity	very complex	Complicated technology
	Flexibility	no flexibility	This choice needs high investments in high capacities and will rule out the possibility to change directions for many years
	Minimum scale	> 300.000 tons/yr	Strong economy of scale
	Knowledge c.a.	high level	High level of knowledge, experience and technological environment needed.
	Connections	> 10 MW	No easy connection to existing network.
Financial	Capital needed	€ 300 mln	When implemented for nearly 100% of available waste. When implemented for 300.000 ton/yr, € 130 mln needed
	Gatefee	€ 50 per ton	Gatefee needed to achieve zero cumulative cashflow in 15 years
Landfill	Prevention use	75%	25% remains as ashes and slags.
Environment/social	GHG emission	reduction of 110.000 tons of CO_2 per year	This reduction is the combined effect of preventing landfill emissions and replacing gas fired electricity production by incineration of all available waste. It should be noted that here, CO_2 emissions at existing landfills are not abated.
	Waste hierarchy effect	negative	Big dilemma. Gatefee will urge towards prevention and recycling but investments will need certainty about waste volumes to be delivered.
	Public acceptance	negative	Strong resistance may be expected.
Energy	Production potential	350 GWH/yr	In case all waste would be used in this option. Around 8% of West Bank consumption.
	LCOE	€ 150/MWh	At a discounting rate of 8%.
Other	Planning	5 years	Time needed for preparation and construction
	Institutions	strong effect	This technology would need the set up of a dedicated public utility company for performing this complex process. Because the West Bank and the Palestine authorities do not have the needed know how, a PPP with a private company would be an option. It would also be necessary to include a private party because the production of electricity is a legal privilege assigned to private operators.
	Risks	higher risks	Water consumption may make this option unrealistic. Dioxine emissions standards must be taken into account when considering this option. A substantial part of e-production on the West Bank would become dependant of one or two high tech waste treatment facilities.

TABLE 10. SUMMARY OF ASSESSMENT FOR DIRECT INCINERATION

It shows that, in case all waste in the West Bank would be incinerated, this option would be able to provide 300 GWh/yr. It would need an investment of at least € 300 million and would have a number of negative effects, uncertainties and risks.

The major downside is the LCOE of € 160 per MWh. However, also here it could be argued that it would be strange to assign all investments and operational costs to the energy production whereas also the treatment of waste would benefit from this investment. But even in the case in which the revenues from a gatefee of €10 per ton were to be distracted from the costs, the LCOE would still be € 140 per MWh.

Also in case the calculation would be reversed with an input of 7 eurocents as a fixed price per kWh, the operations would need a gatefee of € 55 per ton in order to reach zero cumulative cashflow in 15 years.

The reduction of CO_2 emissions in this option would be even higher than in the case of option 1 because here the replacement of emissions from regular gas fired electricity production can be added on the positive side.

Implementing incineration normally leads to high resistance of the population in the region.

Assessment option 3. Anaerobic digestion.

The table below summarises the assessment of this option.

Categorie	Aspects	Score	Explanation
Technical	**Complexity**	**some complexity**	Dedicated technology
	Flexibility	**some flexibility**	Flexible because investments can be performed in smaller portions when compared to incineration
	Minimum scale	**> 30.000 tons/yr**	Some economy of scale
	Knowledge c.a.	**certain level**	Intermediate levels of knowledge, experience and technological environment needed.
	Connections	**< 10 MW**	Needed connection can be applied to existing network.
Financial	**Capital needed**	**€ 150 mln**	When implemented for nearly 100% of all available organic waste.on the West Bank. When implemented for only 50.000 ton/yr, € 23 mln needed
	Gatefee	**€ 105 per ton**	Gatefee needed to achieve zero cumulative cashflow in 15 years when costs of separate collection are included. If these are excluded a gatefee of € 75 is needed
Landfill	**Prevention use**	**50%**	50% of the waste is assumed to be usable for anaerobic digestion
Environment/social	**GHG emission**	**reduction of 90.000 tons of CO_2 per year**	The reduction is comparable to the one of option 1 although in this case there will still remain a need for capping of the landfill because the remaining waste that still has to be landfilled will still contain organic materials. This option will also not abate already existing emissions from the landfills.
	Waste hierarchy effect	**positive**	Positive because, next to the production of energy, this option produces compost. And maybe more important: it introduces separate collection, opening up options for further recycling of plastics, paper etc.
	Public acceptance	**no effects**	No resistance expected.
Energy	**Production potential**	**40 GWH/yr**	In case all waste would be used in this option. Around 1% of West Bank consumption.
	LCOE	**€ 840/MWh**	At a discounting rate of 8%. Costs of separate collection included. If these are excluded still an LCOE of € 670 per MWh would remain,
Other	**Planning**	**2-5 years**	This is the time needed for preparation and construction.
	Institutions	**some effects**	Can be performed by existing JSC's but needs input of knowhow from a private operator. It would also be necessary to include a private party because the production of electricity is a legal privilege assigned to private operators.
	Risks	**some risks**	No excessive risks expected

TABLE 11 SUMMARY OF ASSESSMENT FOR ANAEROBIC DIGESTION

It turns out that anaerobic digestion is expensive, both when it comes to producing electricity and when it comes to the gate fee for incoming waste. In this option the separate collection of organic waste is taken into account at a cost of € 20 per ton of biowaste. This means that all costs of separate collection are allocated to only 50% of the waste being the waste entering the anaerobic digestion. In case these costs would be neglected the conclusion are only slightly more positive.

The other criteria are rather positive. Investing in AD is flexible, needs intermediate input levels of knowledge, does not disrupt present organisational setups and is not expected to cause any resistance nor risks. One other downside that has to be highlighted is the options dependency on the introduction of separate collection this may take up to 5 years in order to implement this waste collection to its full extent.

Assessment option 4. Composting.

Composting is the only non-energy option in this study. It will be used to illustrate whether there are other technologies that may be interesting and might protect the decision-making from to much focus on “energy-only” alternatives.

The table below summarises the assessment of this option.

Categorie	Aspects	Score	Explanation
Technical	Complexity	very simple	Simple technology
	Flexibility	very flexible	Flexible because investments are low and can be performed in smaller portions when compared to incineration
	Minimum scale	> 30.000 tons/yr	Some economy of scale
	Knowledge c.a.	low level	Low levels of knowledge, experience and technological environment needed.
	Connections	n.a.	No needed connection to the network.
Financial	Capital needed	€ 25 mln	When implemented for nearly 100% of all available organic waste.on the West Bank. When implemented for only 50.000 ton/yr, € 5 mln needed
	Gatefee	€ 35 per ton	Gatefee needed to achieve zero cumulative cashflow in 15 years when costs of separate collection are included. If these are excluded a gatefee of € 15 is needed
Landfill	Prevention use	50%	50% of the waste is assumed to be usable for composting
Environment/social	GHG emission	reduction of 80.000 tons of CO_2 per year	The reduction is comparable to the one of option 1 although in this case there will still remain a need for capping of the landfill because the remaining waste that still has to be landfilled will still contain organic materials. This option will also not abate already existing emissions from the landfills.
	Waste hierarchy effect	positive	Positive because, next to the production of energy, this option produces compost. And maybe more important: it introduces separate collection, opening up options for further recycling of plastics, paper etc.
	Public acceptance	no effects	No resistance expected.
Energy	Production potential	0	
	LCOE	n.a.	
Other	Planning	1-5 years	Mostly time needed for preparation and construction
	Institutions	no effects	Can be performed by existing JSC’s.
	Risks	no risks	No risks expected

TABLE 11 SUMMARY OF ASSESSMENT FOR COMPOSTING

Compost produces no energy. Its strength lies in the reduction of landfilling at low investments and costs.

The positive aspects are comparable to that of anaerobic digestion and, also here, there is a downside that has to be highlighted. It is that also composting needs the introduction of separate collection which may take up to 5 years in order to implement this waste collection to its full extent.

Overall assessment

The table below provides an overview of the assessment results.

In general, and without weighing the criteria, it can be concluded that option 1, comprising the extraction of landfill gas and electricity production from this collected gas, can be considered as a “no-regret” option. No matter what scenario will be chosen, this option should always be included because it is the only option that abates existing emissions from the landfills.

Categorie	Aspects	landfill gas extraction	direct incineration	anaerobic digestion	composting
Technical	Complexity	low	very complex	some complexity	very simple
	Flexibility	very high	no flexibility	some flexibility	very flexible
	Minimum scale	n.a.	> 300.000 tons/yr	> 30.000 tons/yr	> 30.000 tons/yr
	Knowledge c.a.	low	high level	certain level	low level
	Connections	< 10 MW	> 10 MW	< 10 MW	n.a.
Financial	Capital needed	€ 30 mln	€ 300 mln	€ 150 mln	€ 25 mln
	Gatefee	€ 0,50 per ton	€ 50 per ton	€ 105 per ton	€ 35 per ton
Landfill	Prevention use	0%	75%	50%	50%
Environment/social	GHG emission	reduction of 80.000 tons of CO_2 per year	reduction of 110.000 tons of CO_2 per year	reduction of 90.000 tons of CO_2 per year	reduction of 80.000 tons of CO_2 per year
	Waste hierarchy effect	no effect	negative	positive	positive
	Public acceptance	high	negative	no effects	no effects
Energy	Production potential	40 GWH/yr	350 GWH/yr	40 GWH/yr	0
	LCOE	€ 69/MWh	€ 150/MWh	€ 840/MWh	n.a.
Other	Planning	2 years	5 years	2-5 years	1-5 years
	Institutions	no effects	strong effect	some effects	no effects
	Risks	no effects	higher risks	some risks	no risks

TABLE 12. ASSESSMENT SUMMARY

The assessment of direct incineration is less uniform. On the one hand it is the scenario with the highest potential for electricity production, prevention of GHG production and reduction of landfill use. On the other side it is clear that it will need either high gate-fees or a high feed-in tariff for produced electricity. Complexity, needed scale, institutional effects, planning and risks are important extra considerations in evaluating this scenario.

The financial effects of anaerobic digestion are less promising than those of incineration. The preparation and construction time needed for this option is shorter but the planning is linked to the needed introduction of separate collection. Separate collection can be introduced stepwise, starting with those municipalities and city-quarters that are thought to be most promising with regard to the participation of the population. For this reason a stepwise growth can be assumed with a first production capacity after within 3 years. Nevertheless this will not make up for the high gate-fees and electricity prices that are needed.

Although composting does not produce energy, its performance with regard to most other criteria makes it worth considering.

The necessity of separate collection for anaerobic digestion and composting has an upside. It enables the authorities to also consider other options of recycling of paper, plastics and glass.

4.3. Q&A's and scenarios

In this paragraph a number of questions will be answered in order to provide some more practical input for further decision making.

1. What could be the effect of a combined landfill gas and composting scenario (options 1 and 4)?

Such a scenario would need immediate actions on landfill capping and gas extraction/reuse. A composting facility will have to be constructed and in the first years it would be used as a pre treatment before landfilling the waste. All the waste would be separated by sieving into a wet and dry fraction and the wet fraction would be composted in order to make a product that can be used for daily coverage of the remaining waste. The scenario could be implemented within 1-2 years. Gradually separate collection will be introduced leading to a stepwise replacement of the production of coverage material by the production of reusable compost. It would lead to the following effects:

Scenario	continuing the present situation	combining options 1 and 4
effect on landfill capacity	10 years	15-20 years
effect on GHG emissions	no reduction	reduction of 80.000 tons CO_2/year
effect on energy production	no production	production of 30-35 GWh/year
effect on overall waste management costs	no effect	extra costs €10-15 per ton gradually growing towards € 25 per ton when 100% is composted

TABLE 13. EFFECTS OF COMBINING OPTIONS 1 AND 4

2. What would be the effect for all options on the present landfill capacity?

At this moment the landfill capacity may serve to accommodate 10 more years of waste production on the West Bank.

- The startup of an incineration capacity of 500.000 tons/year in 2023 would lead to 2-3 additional years.
- The startup of 500.000 tons/year capacity of anaerobic digestion in 2022 would lead to 4-5 additional years.
- The startup of 500.000 tons/year of composting in 2020, as described under question 1, would lead to 6-7 additional years.

3. How does direct incineration compare to PV energy?

When comparing direct incineration to PV the following aspects will be relevant:

Aspect	Direct incineration	Photo Voltaic solar
Capital expenses (€ per installed MWh/yr)	860	750
LCOE (€ cents per kWh)	15	8,5
Production prophile	continuous operation	only daytime production
Implementation prophile	one large step	multiple small steps
Land use	low	high

TABLE 14. COMPARING DIRECT INCINERATION AND PV SOLAR

Direct incineration comes in large steps with higher capital expenses and LCOE's whereas PV needs storage capacities and faces high land use.

4. What would be the effect if investments for incineration would be fully or partly granted by donors?

Capital expenses for incineration are high. If the € 110 mln needed for a 300.000 ton/year were granted, the LCOE for electricity produced through incineration would be € 105/MWh and € 55/MWh at 50% and 100% grant respectively. This last scenario would make incineration more attractive.

5. Can we define a scenario in which we would not need to construct new landfill capacity?

No, that is not possible. Even with combining all options it would still be necessary to landfill, for example, the residues of incineration and other recycling options.

6. What could be the effect of other options for recycling of waste?

An important option would be to consider a programmed approach for construction and demolition waste. In general it can be expected that the volume of this waste outnumbers that of municipal waste. Unfortunately there are no data available on this waste in the West Bank. It might be the case that a part of this waste is collected together with municipal waste and ends up on the two landfills. If so, it would be interesting to study this percentage and set up a program to divert it towards a recycling facility.
The other option would be to treat the residual waste that remains after separate collection. Options would be to separate paper, plastics and glass for recycling.

7. What other options might be available for combining waste and energy?

As already mentioned earlier in the report, the slopes of the landfills are fit for the construction of PV-solar parks. This can be done directly after the slopes are covered; there is no need to wait for the entire closure of the landfills.
Another option may lie in separately collecting wasted wood from several sources such as construction and demolition waste. The wood waste could then be shredded and fed into a small scale biomass incinerator.

8. What are the most important institutional effects?

Institutional effects are relevant when adequately allocating responsibilities with regard to investments and operations. In general, municipalities can be seen as the authorities having the first responsibility for waste management services. In all scenario's city cleaning and (separate) collection remain under their direct control. Because the municipalities do not always have the scale and knowledge needed for transfer, transport and landfill they can delegate these activities to the JSC's as is done already in most municipalities. This delegation has another positive effect: it gives the opportunity to separate political and operational responsibilities. For the treatment options the optimal attribution of responsibilities would be:

- The JSC's would of course be the party to invest and operate landfill gas extraction. Application of the capping, collection and engines would need to be procured by public tendering.
- The JSC's knowhow and experience will also be suitable to accommodate investments and operations for composting. Outsourcing would be possible but is not needed. By doing it themselves the JSC's are challenged to build up their own experiences in this field. Outsourcing or selling these activities to private parties may be considered in the future.
- For anaerobic digestion the JSC's will lack the knowhow. It can be provided by setting up PPP's with private companies or even 100% outsourcing of this type of treatment by tendering contracts. This would however require substantial external support of the JSC's.
- For incineration the technological demands are even more challenging. A PPP or tendered longterm concession is needed. In this case the joint JSC's have to set up an additional cooperation amongst each other in order to provide the needed scale for this concession.

The institutional effects can be summarised as follows.

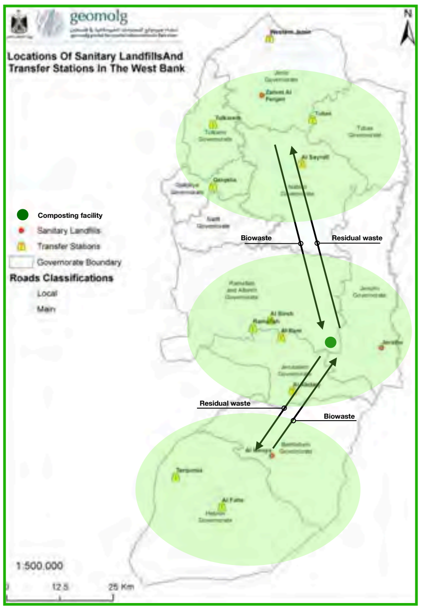
Responsibilities	landfill gas extraction and e-production	composting	anaerobic digestion	incineration
financing	Financing will have to be performed by the JSC's, possibly with the help of donors	Financing can be done by the JSC's.	Financing can be done by the JSC's.	Financing, design, construction and operation can and should be sourced out as long term concessions to international companies with sufficient references.
design	To be outsourced by the JSC's to specialised engineering firms.	Design can be done by the JSC's.	Design, construction and operation (and possibly also financing) should preferably be in the hands of private contractors/ operators. JSC's could opt to take over installations and operations after 5 years or as soon as stable operations and adequate knowledge levels are reached.	
construction	To be outsourced to private (international) contractors with adequate references.	Construction can be procured based on JSC design.		
operation and maintenance	Operation and maintenance of e-production legally has to be in the hands of private players. Synergy requires that these operations are in the hand of one operator and for this reason it is advisable to source out gas extraction and e-production as one integrated package.	Operations can be performed by the JSC's, similar to the landfills. Full or partly outsourcing of financing, design, construction and operation can be considered but only when multiple, sufficiently experienced, private bidders are interested.		

TABLE 15. PREFERABLE ALLOCATION OF RESPONSIBILITIES

9. What are the best locations to invest in these options?

Looking at the four different options:

- With regard to landfill gas extraction there is of course no other option than to do this at the landfills.
- Composting can be done at the 2 landfill sites, especially in the first stages of a scenario as described under question 1. A third or fourth composting facility, aiming at the production of marketable compost, would preferably be operated more to the center of the West Bank, near Ramallah or Jericho. This would give the opportunity to optimise transports and to spread the burdens and nuisances of waste treatment plants over the region. If composting were to be located in Ramallah or Jericho it would, for example, mean that trucks with residual waste would drive from these municipalities to the landfills of Jenin or Bethlehem and on the way back they would take biowaste from these last municipalities to the composting facilities in Ramallah/Jericho (see graph 16.)
- Anaerobic digestion would need a similar approach as composting.
- Incineration needs to be sited at locations with good access to water (for steam production) and to high voltage grids in order to be able to evacuate produced power.



GRAPH 16. TRANSPORTS OF BIOWASTE AND RESIDUAL WASTE

5. Evaluation and discussion

The conclusion of this assessment is that direct incineration has the highest potential with regard to production of electricity, prevention of GHG emissions and reduction of landfill use. At the same time this option has some serious drawbacks with regard to needed minimum scale, needed capital and resulting LCOE (levelised cost of electricity).

Enhanced landfill gas extraction displays a lower potential but also needs less capital and gives an affordable LCOE. This is a no-regret option also because it has a high and cheap effect on GHG emissions and reduction of existing nuisances around the landfills.

Anaerobic digestion turns out to give a high LCOE combined with a number of other downsides.

The advise would be:

1. Implement landfill gas extraction and electrification, irrespective of other scenarios to be chosen.
2. Further weigh and discuss all aspects of direct incineration within the context of the West Bank situation.
3. When choosing not to implement incineration, consider the stepwise introduction of separate collection and composting on the regional level.
4. The two landfills on the West Bank still provide some capacity. It is strongly advised to install this capacity and use the created time to implement the above options.

Annex 1 Summary of meetings and visits

program August 2018

Day	Timing	Organisation and representatives
Monday 6th	Morning	Meeting with the Netherlands Representative office, Mrs. Subha Ghannam
	Afternoon	Meeting with Ministry of Local Government, Mr. Suleiman Abu Muferreh
Tuesday 7th	Morning	Meeting with Palestine Energy and Natural Resources Agency, Mr. Ayman Ismail, Basel Yaseen and Fabian Odeh
	Morning	Meeting with Jica, Mrs Mariko Chiba
	Afternoon	Meeting with Ramallah municipality, Mrs Malvina Aljamal, Mr. Ghazal and mayor Musa Hadid
Wednesday 8th	Morning	Meeting with Joint Service Council Jenin, Mr Hani Sawanneh, Mr. Mohammed Al-Sadi
	Afternoon	Visit to landfill
Thursday 9th	Morning	Meeting with Joint Service Council Bethlehem/Hebron with Mr Suleiman Abu Muferreh, Majed Al Sari, Ahmad Sokar
	Afternoon	Meeting with Environmental Quality Agency, Mr. Abu Thaher and Mr. Yaser Abu Shanab
Friday 10th	Morning	Meeting with World Bank. Chris Pablo
	Afternoon	Meeting with UNDP , Mrs. Rima Abumiddain and Mr. Husam Tubail

Annex 2. Calculation of equivalent CO2 emissions from landfills in different scenario's

The equations below calculate the emission of equivalent CO_2 tons for different landfill scenario's. In these equations the effects of 85% availability of the gas-engine and 5% of in-house use of electricity for gas-suction are neglected.

The upper formula relates the total gas production to the tonnage of CO_2 equivalents emitted in a situation without preventive measures. The only reduction comes from oxidation of the methane in the upper waste layers before the gas emits. The middle formula does the same but now in a situation with gas collection and flaring of the gas. The lower formula does the same but now in a situation with using the gas for electricity production.

no prevention

$$\boxed{\text{tonnage of } CO_2 \text{ emission emitted}} = \boxed{\text{total gas production in } m^3} \times \left(\boxed{CO_2 \text{ content } 40\%} \times \boxed{CO_2 \text{ to tons conversion } 0{,}0018} + \boxed{\text{methane content } 60\%} \times \boxed{CH_4\ m^3 \text{ to tons } CO_2 \text{ conversion } 0{,}00024} \times \left(\boxed{\text{oxidation ratio of } 10\%} + \boxed{\text{non-oxidation ratio of } 90\%} \times \boxed{CO_2/CH_4 \text{ conversion factor of } 28} \right) \right) = \boxed{\text{total gas production in } m^3} \times \boxed{0{,}0044}$$

collection and flaring

$$\boxed{\text{tonnage of } CO_2 \text{ emission emitted}} = \boxed{\text{total gas production in } m^3} \times \left(\boxed{\text{collection inefficiency of } 15\%} \times \left(\boxed{CO_2 \text{ content } 40\%} \times \boxed{CO_2 \text{ to tons conversion } 0{,}0018} + \boxed{\text{methane content } 60\%} \times \boxed{CH_4\ m^3 \text{ to tons } CO_2 \text{ conversion } 0{,}00024} \times \left(\boxed{\text{oxidation ratio of } 10\%} + \boxed{\text{non-oxidation ratio of } 90\%} \times \boxed{CO_2/CH_4 \text{ conversion factor of } 28} \right) \right) + \boxed{\text{collection efficiency of } 85\%} \times \left(\boxed{CO_2 \text{ content } 40\%} \times \boxed{CO_2 \text{ to tons conversion } 0{,}0018} + \boxed{\text{methane content } 60\%} \times \boxed{CH_4\ m^3 \text{ to tons } CO_2 \text{ conversion } 0{,}00024} \right) \right) = \boxed{\text{total gas production in } m^3} \times \boxed{0{,}0014}$$

collection and e-production

$$\boxed{\text{tonnage of } CO_2 \text{ emission emitted}} = \boxed{\text{total gas production in } m^3} \times \left(\boxed{\text{collection inefficiency of } 15\%} \times \left(\boxed{CO_2 \text{ content } 40\%} \times \boxed{CO_2 \text{ to tons conversion } 0{,}0018} + \boxed{\text{methane content } 60\%} \times \boxed{CH_4\ m^3 \text{ to tons } CO_2 \text{ conversion } 0{,}00024} \times \left(\boxed{\text{oxidation ratio of } 10\%} + \boxed{\text{non-oxidation ratio of } 90\%} \times \boxed{CO_2/CH_4 \text{ conversion factor of } 28} \right) \right) + \boxed{\text{collection efficiency of } 85\%} \times \boxed{CO_2 \text{ content } 40\%} \times \boxed{CO_2 \text{ to tons conversion } 0{,}0018} \right) = \boxed{\text{total gas production in } m^3} \times \boxed{0{,}0013}$$

Annex 3. Businesscases landfill gas extraction for Jenin and Bethlehem

enhanced landfill gas Jenin

		totals or inputs	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034
				1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
gas production	m³/hr	22.800	0	1.300	1.400	1.500	1.600	1.600	1.600	1.600	1.600	1.600	1.600	1.600	1.600	1.500	1.400	1.300
gas production corrected	m³/yr	174.762.00	0	9.964.500	10.731.000	11.497.500	12.264.000	12.264.000	12.264.000	12.264.000	12.264.000	12.264.000	12.264.000	12.264.000	12.264.000	11.497.500	10.731.000	9.964.500
potential electrical capacity	MW	- -	0	2.724	2.934	3.143	3.353	3.353	3.353	3.353	3.353	3.353	3.353	3.353	3.353	3.143	2.934	2.724
production capacity in operation	MW	- -	0,0	2,5	2,5	3,0	3,0	3,0	3,0	3,0	3,0	3,0	2,5	2,5	2,5	2,5	2,5	2,5
production of MWh (0,85% upt)	MWh/yr	305.286	0	18.615	18.615	22.338	22.338	22.338	22.338	22.338	22.338	22.338	18.615	18.615	18.615	18.615	18.615	18.615
electricity revenues	€	21.370.020	0	1.303.050	1.303.050	1.563.660	1.563.660	1.563.660	1.563.660	1.563.660	1.563.660	1.563.660	1.303.050	1.303.050	1.303.050	1.303.050	1.303.050	1.303.050
received tonnage of waste	tons/yr	8.892.765	424.050	438.892	454.253	470.152	486.607	503.638	521.266	539.510	558.393	577.937	598.164	619.100	640.769	663.196	686.407	710.432
gatefee revenues	€	4.446.383	212.025	219.446	227.126	235.076	243.304	251.819	260.633	269.755	279.196	288.968	299.082	309.550	320.384	331.598	343.204	355.216
electricity price	€/kWh	0,07																
gatefee	€/ton	0,5																
Investments	k€	16.000	2.000	3.500	2.500	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0	0	0	0	0
Operational expenses	k€	3.450	150	150	150	300	300	300	300	300	300	300	150	150	150	150	150	150
Revenues	k€	25.816	212	1.522	1.530	1.799	1.807	1.815	1.824	1.833	1.843	1.853	1.602	1.613	1.623	1.635	1.646	1.658
Operating/investments cashflow	k€	6.366	-1.938	-2.128	-1.120	499	507	515	524	533	543	553	452	1.463	1.473	1.485	1.496	1.508
Cum. operating/investments cf	k€	- -	-1.938	-4.065	-5.185	-4.687	-4.180	-3.664	-3.140	-2.606	-2.064	-1.511	-1.059	404	1.877	3.362	4.858	6.366
Financial cashflow	k€	-5.720	1.840	2.140	1.020	-480	-480	-480	-480	-480	-480	-480	-480	-1.400	-1.320	-2.160	-2.000	0
Total cashflow	k€	646	-98	12	-100	19	27	35	44	53	63	73	-28	63	153	-675	-504	1.508
Cumulative total cashflow	k€	- -	-98	-85	-185	-167	-140	-104	-60	-6	56	129	101	164	317	-358	-862	646
loan for investments	k€	16.000	2.000	3.500	2.500	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0	0	0	0	0
loan for working capital	k€	12.000	0	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0	0	0
Total loans	k€	28.000	2.000	4.500	3.500	2.000	2.000	2.000	2.000	2.000	2.000	2.000	2.000	1.000	1.000	0	0	0
loan repayments	k€	28.000	0	2.000	2.000	2.000	2.000	2.000	2.000	2.000	2.000	2.000	2.000	2.000	2.000	2.000	2.000	0
Remaining loan	k€	- -	2.000	4.500	6.000	6.000	6.000	6.000	6.000	6.000	6.000	6.000	6.000	5.000	4.000	2.000	0	0
interest (8%)	k€	5.720	160	360	480	480	480	480	480	480	480	480	480	400	320	160	0	0
discounting ratio		8%																
year number			0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	
sum of costs	k€		2.150	3.650	2.650	1.300	1.300	1.300	1.300	1.300	1.300	1.300	1.150	150	150	150	150	150
discounted cash out	k€	14.517	2.150	3.380	2.272	1.032	956	885	819	759	702	650	533	64	60	55	51	150
sum of energy	MW/yr	188.700	0	17.236	15.959	17.733	16.419	15.203	14.077	13.034	12.069	11.175	8.622	7.984	7.392	6.845	6.338	18.615
LCOE	€/MWh	77																

enhanced landfill gas Bethlehem

		totals or inputs	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034
				1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
gas production	m³/hr	21.000	0	700	800	900	1.000	1.200	1.300	1.400	1.500	1.500	1.600	1.700	1.700	1.800	1.900	2.000
gas production corrected	m³/yr	160.965.00	0	5.365.500	6.132.000	6.898.500	7.665.000	9.198.000	9.964.500	10.731.000	11.497.500	11.497.500	12.264.000	13.030.500	13.030.500	13.797.000	14.563.500	15.330.000
potential electrical capacity	MW	- -	0	1.467	1.676	1.886	2.095	2.514	2.724	2.934	3.143	3.143	3.353	3.562	3.562	3.772	3.981	4.191
production capacity in operation	MW	- -	0,0	1,5	2,0	2,0	2,5	2,5	3,0	3,0	3,0	3,0	3,5	3,5	4,0	4,0	4,0	4,0
production of MWh (0,85% upt)	MWh/yr	338.793	0	11.169	14.892	14.892	18.615	18.615	22.338	22.338	22.338	22.338	26.061	26.061	29.784	29.784	29.784	29.784
electricity revenues	€	23.715.510	0	781.830	1.042.440	1.042.440	1.303.050	1.303.050	1.563.660	1.563.660	1.563.660	1.563.660	1.824.270	1.824.270	2.084.880	2.084.880	2.084.880	2.084.880
received tonnage of waste	tons/yr	7.275.899	346.950	359.093	371.662	384.670	398.133	412.068	426.490	441.417	456.867	472.857	489.407	506.536	524.265	542.615	561.606	581.262
gatefee revenues	€	3.637.949	173.475	179.547	185.831	192.335	199.067	206.034	213.245	220.709	228.433	236.429	244.704	253.268	262.133	271.307	280.803	290.631
electricity price	€/kWh	0,07																
gatefee	€/ton	0,5																
Investments	k€	14.000	0	1.500	2.500	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0	0	0
Operational expenses	k€	4.350	150	150	450	300	300	300	300	300	300	300	450	450	150	150	150	150
Revenues	k€	27.353	173	961	1.228	1.235	1.502	1.509	1.777	1.784	1.792	1.800	2.069	2.078	2.347	2.356	2.366	2.376
Operating/investments cashflow	k€	9.003	23	-689	-1.722	-65	202	209	477	484	492	500	619	628	1.197	2.206	2.216	2.226
Cum. operating/investments cf	k€	- -	23	-665	-2.387	-2.452	-2.250	-2.041	-1.564	-1.080	-588	-87	532	1.159	2.356	4.562	6.778	9.003
Financial cashflow	k€	-1.800	0	460	1.340	-160	760	-240	-240	-240	-240	-1.160	-1.080	-1.000	0	0	0	0
Total cashflow	k€	7.203	23	-229	-382	-225	962	-31	237	244	252	-660	-461	-372	1.197	2.206	2.216	2.226
Cumulative total cashflow	k€	- -	23	-205	-587	-812	150	119	356	600	852	193	-268	-641	556	2.762	4.978	7.203
loan for investments	k€	14.000	0	1.500	2.500	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0	0	0
loan for working capital	k€	5.000	0	0	0	0	1.000	1.000	1.000	1.000	1.000	0	0	0	0	0	0	0
Total loans	k€	19.000	0	1.500	2.500	1.000	2.000	2.000	2.000	2.000	2.000	1.000	1.000	1.000	1.000	0	0	0
loan repayments	k€	19.000	0	1.000	1.000	1.000	1.000	2.000	2.000	2.000	2.000	2.000	2.000	2.000	1.000	0	0	0
Remaining loan	k€	- -	0	500	2.000	2.000	3.000	3.000	3.000	3.000	3.000	2.000	1.000	0	0	0	0	0
interest	k€	1.800	0	40	160	160	240	240	240	240	240	160	80	0	0	0	0	0
discounting ratio		8%																
year number			0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	
sum of costs	k€		150	1.650	2.950	1.300	1.300	1.300	1.300	1.300	1.300	1.300	1.450	1.450	1.150	150	150	150
discounted cash out	k€	12.016	150	1.528	2.529	1.032	956	885	819	759	702	650	672	622	457	55	51	150
sum of energy	MW/yr	197.588	0	10.342	12.767	11.822	13.683	12.669	14.077	13.034	12.069	11.175	12.071	11.177	11.828	10.952	10.140	29.784
LCOE	€/MWh	61																

Annex 4. Businesscase direct incineration

direct incineration

		totals or inputs	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036
						1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Energy input	**GJ/yr**	40.500.000	0	0	0	2.700.000	2.700.000	2.700.000	2.700.000	2.700.000	2.700.000	2.700.000	2.700.000	2.700.000	2.700.000	2.700.000	2.700.000	2.700.000	2.700.000	2.700.000
production of MWh	**MWh/yr**	2.250.000	0	0	0	150.000	150.000	150.000	150.000	150.000	150.000	150.000	150.000	150.000	150.000	150.000	150.000	150.000	150.000	150.000
electricity revenues	**k€**	157.500.00(	0	0	0	10.500.000	10.500.000	10.500.000	10.500.000	10.500.000	10.500.000	10.500.000	10.500.000	10.500.000	10.500.000	10.500.000	10.500.000	10.500.000	10.500.000	10.500.000
received tonnage of waste	**tons/yr**	4500000	0	0	0	300.000	300.000	300.000	300.000	300.000	300.000	300.000	300.000	300.000	300.000	300.000	300.000	300.000	300.000	300.000
gatefee revenues	**k€**	225000000	0	0	0	15.000.000	15.000.000	15.000.000	15.000.000	15.000.000	15.000.000	15.000.000	15.000.000	15.000.000	15.000.000	15.000.000	15.000.000	15.000.000	15.000.000	15.000.000
electricity price	**€/kWh**	0,07																		
gatefee	**€/ton**	50																		
Investments	**k€**	110.000	50.000	50.000	10.000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Operational expenses	**k€**	114.000	3.000	3.000	3.000	7.000	7.000	7.000	7.000	7.000	7.000	7.000	7.000	7.000	7.000	7.000	7.000	7.000	7.000	7.000
Revenues	**k€**	382.500	0	0	0	25.500	25.500	25.500	25.500	25.500	25.500	25.500	25.500	25.500	25.500	25.500	25.500	25.500	25.500	25.500
Operating/investments cashflow	**k€**	158.500	-53.000	-53.000	-13.000	18.500	18.500	18.500	18.500	18.500	18.500	18.500	18.500	18.500	18.500	18.500	18.500	18.500	18.500	18.500
Cum. operating/investments cf	**k€**	- -	-53.000	-106.000	-119.000	-100.500	-82.000	-63.500	-45.000	-26.500	-8.000	10.500	29.000	47.500	66.000	84.500	103.000	121.500	140.000	158.500
Financial cashflow	**k€**	-89.200	60.000	50.400	8.800	-11.200	-20.400	-19.600	-18.800	-22.600	-21.400	-20.200	-19.000	-17.800	-16.600	-10.800	-10.000	0	0	0
Total cashflow	**k€**	69.300	7.000	-2.600	-4.200	7.300	-1.900	-1.100	-300	-4.100	-2.900	-1.700	-500	700	1.900	7.700	8.500	18.500	18.500	18.500
Cumulative total cashflow	**k€**	- -	7.000	4.400	200	7.500	5.600	4.500	4.200	100	-2.800	-4.500	-5.000	-4.300	-2.400	5.300	13.800	32.300	50.800	69.300
loan for investments	**k€**	110.000	50.000	50.000	10.000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
loan for working capital	**k€**	40.000	10000	10000	10000	10000	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total loans	**k€**	150.000	60.000	60.000	20.000	10000	0	0	0	0	0	0	0	0	0	0	0	0	0	0
loan repayments	**k€**	150.000	0	0	0	10.000	10.000	10.000	10.000	15000	15000	15000	15000	15000	15000	10000	10000	0	0	0
Remaining loan	**k€**	0	60.000	120.000	140.000	140.000	130.000	120.000	110.000	95.000	80.000	65.000	50.000	35.000	20.000	10.000	0	0	0	0
interest (8%)	**k€**	89.200	0	9.600	11.200	11.200	10.400	9.600	8.800	7.600	6.400	5.200	4.000	2.800	1.600	800	0	0	0	0
discounting ratio		8%																		
year number			0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
sum of costs	**k€**		53.000	53.000	13.000	7.000	7.000	7.000	7.000	7.000	7.000	7.000	7.000	7.000	7.000	7.000	7.000	7.000	7.000	7.000
discounted cash out	**k€**	164.588	53.000	49.074	11.145	5.557	5.145	4.764	4.411	4.084	3.782	3.502	3.242	3.002	2.780	2.574	2.383	2.207	2.043	1.892
sum of energy	**MW/yr**	1.100.756	0	0	0	119.075	110.254	102.087	94.525	87.524	81.040	75.037	69.479	64.332	59.567	55.155	51.069	47.286	43.784	40.540
LCOE	**€/MWh**	150																		

Annex 5. Businesscase anaerobic biodigestion

anaerobic digestion

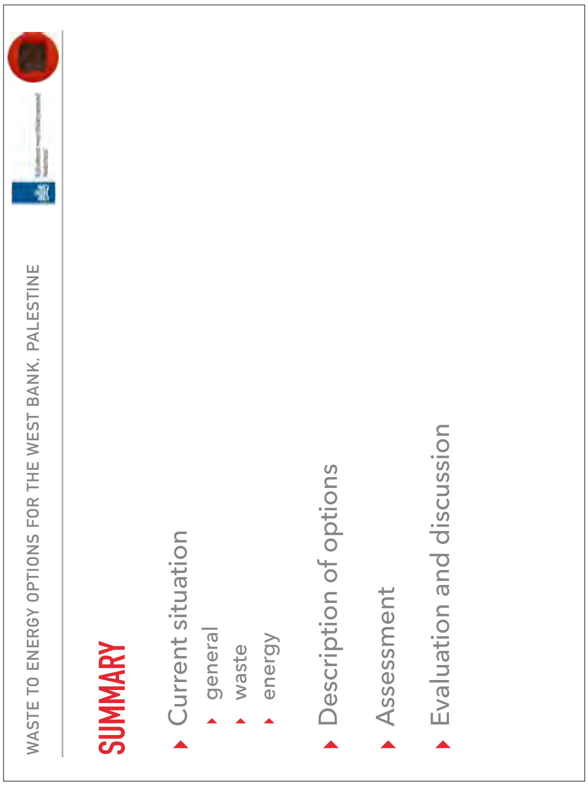
		totals or inputs	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2014
				1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
gas production	m³/hr	5.993	0	400	400	400	400	400	400	400	400	400	400	400	400	400	400	400
production of MWh (0,85% upt)	MWh/yr	89.897	0	5.993	5.993	5.993	5.993	5.993	5.993	5.993	5.993	5.993	5.993	5.993	5.993	5.993	5.993	5.993
electricity revenues	€	6.292.808	0	419.521	419.521	419.521	419.521	419.521	419.521	419.521	419.521	419.521	419.521	419.521	419.521	419.521	419.521	419.521
received tonnage of waste	tons/yr	750.000	0	50.000	50.000	50.000	50.000	50.000	50.000	50.000	50.000	50.000	50.000	50.000	50.000	50.000	50.000	50.000
gatefee revenues	€	78.750.000	0	5.250.000	5.250.000	5.250.000	5.250.000	5.250.000	5.250.000	5.250.000	5.250.000	5.250.000	5.250.000	5.250.000	5.250.000	5.250.000	5.250.000	5.250.000
electricity price	€/kWh	0,07																
gatefee	€/ton	105																
Investments	k€	23.000	23.000	0	0	0	0	0	0	0	0	0						
Operational expenses	k€	35.250	0	2.350	2.350	2.350	2.350	2.350	2.350	2.350	2.350	2.350	2.350	2.350	2.350	2.350	2.350	2.350
Revenues	k€	85.043	0	5.670	5.670	5.670	5.670	5.670	5.670	5.670	5.670	5.670	5.670	5.670	5.670	5.670	5.670	5.670
Operational cashflow EBITDA	k€	26.793	-23.000	3.320	3.320	3.320	3.320	3.320	3.320	3.320	3.320	3.320	3.320	3.320	3.320	3.320	3.320	3.320
Cumulative operational cashflow	k€	- -	-23.000	-19.680	-16.361	-13.041	-9.722	-6.402	-3.083	237	3.556	6.876	10.195	13.515	16.834	20.154	23.473	26.793
Financial cashflow	k€	-22.400	20.700	-500	-4.300	-3.200	-3.100	-3.000	-2.900	-3.700	-3.500	-3.300	-3.100	-2.900	-2.700	-2.500	-2.300	-2.100
Total cashflow	k€	4.393	-2.300	2.820	-980	120	220	320	420	-380	-180	20	220	420	620	820	1.020	1.220
Cumulative total cashflow	k€	- -	-2.300	520	-461	-341	-122	198	617	237	56	76	295	715	1.334	2.154	3.173	4.393
loan for investments	k€	23.000	23.000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
loan for working capital	k€	20.000	0	5000	4000	3000	3000	2000	2000	1000	0	0	0	0	0	0	0	
Total loans	k€	43.000	23.000	5.000	4.000	3.000	3.000	2.000	2.000	1.000	0	0	0	0	0	0	0	0
loan repayments	k€	42.000	0	3000	6000	4000	4000	3000	3000	3000	2000	2000	2000	2000	2000	2000	2000	2000
Remaining loan	k€	- -	23.000	25.000	23.000	22.000	21.000	20.000	19.000	17.000	15.000	13.000	11.000	9.000	7.000	5.000	3.000	1.000
interest	k€	23.400	2.300	2.500	2.300	2.200	2.100	2.000	1.900	1.700	1.500	1.300	1.100	900	700	500	300	100
discount ratio		0,08																
year number			0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
sum of costs	k€		23.000	2.350	2.350	2.350	2.350	2.350	2.350	2.350	2.350	2.350	2.350	2.350	2.350	2.350	2.350	2.350
discounted cash out	k€	43.115	23.000	2.176	2.015	1.866	1.727	1.599	1.481	1.371	1.270	1.176	1.089	1.008	933	864	800	741
sum of energy	MW/yr	51.298	0	5.549	5.138	4.758	4.405	4.079	3.777	3.497	3.238	2.998	2.776	2.570	2.380	2.204	2.040	1.889
LCOE	€/MWh	840																

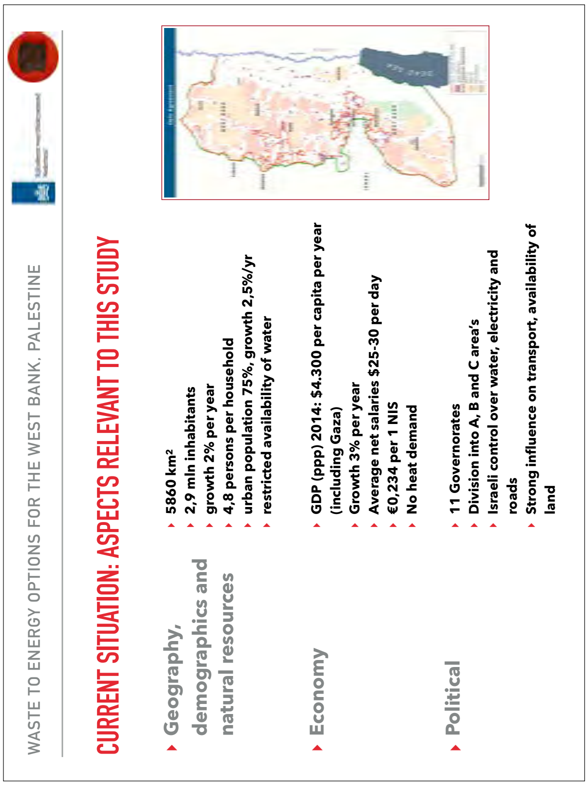
Annex 6. Businesscase composting

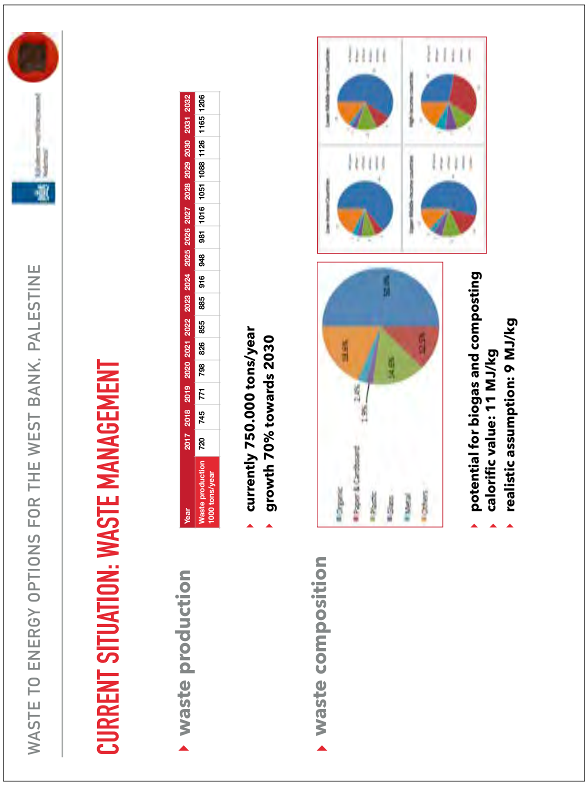
composting

		totals or inputs	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034
				1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
received tonnage of waste	tons/yr	750.000	0	50.000	50.000	50.000	50.000	50.000	50.000	50.000	50.000	50.000	50.000	50.000	50.000	50.000	50.000	50.000
gatefee revenues	€	27.000.000	0	1.800.000	1.800.000	1.800.000	1.800.000	1.800.000	1.800.000	1.800.000	1.800.000	1.800.000	1.800.000	1.800.000	1.800.000	1.800.000	1.800.000	1.800.000
gatefee	€/ton	36																
Investments	k€	3.000	3.000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Operational expenses	k€	22.500	0	1.500	1.500	1.500	1.500	1.500	1.500	1.500	1.500	1.500	1.500	1.500	1.500	1.500	1.500	1.500
Revenues	k€	27.000	0	1.800	1.800	1.800	1.800	1.800	1.800	1.800	1.800	1.800	1.800	1.800	1.800	1.800	1.800	1.800
Operating/investments cashflow	k€	1.500	-3.000	300	300	300	300	300	300	300	300	300	300	300	300	300	300	300
Cum. operating/investments cf	k€	- -	-3.000	-2.700	-2.400	-2.100	-1.800	-1.500	-1.200	-900	-600	-300	0	300	600	900	1.200	1.500
Financial cashflow	k€	-1.750	3.000	-300	-750	-700	-650	-600	-550	-500	-450	-400	-350	-300	200	200	200	200
Total cashflow	k€	-250	0	0	-450	-400	-350	-300	-250	-200	-150	-100	-50	0	500	500	500	500
Cumulative total cashflow	k€	- -	0	0	-450	-850	-1.200	-1.500	-1.750	-1.950	-2.100	-2.200	-2.250	-2.250	-1.750	-1.250	-750	-250
loan for investments	k€	3.000	3.000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
loan for working capital	k€	500	0	500	0	0	0	0	0	0	0	0						
Total loans	k€	3.500	3.000	500	0	0	0	0	0	0	0	0	0	0	0	0	0	0
loan repayments	k€	5500	0	500	500	500	500	500	500	500	500	500	500	500	0	0	0	0
Remaining loan	k€	- -	3.000	3.000	2.500	2.000	1.500	1.000	500	0	-500	-1.000	-1.500	-2.000	-2.000	-2.000	-2.000	-2.000
interest (8%)	k€	-250	0	300	250	200	150	100	50	0	-50	-100	-150	-200	-200	-200	-200	-200

Annex 7. Presentation Ramallah, November 14th, 2018



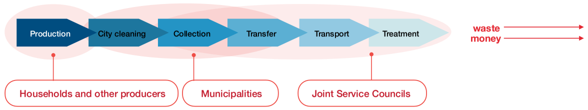




WASTE TO ENERGY OPTIONS FOR THE WEST BANK, PALESTINE

CURRENT SITUATION: WASTE MANAGEMENT

- organisation



- services/facilities
  - ~ 100% collection
  - 11 transfer stations
  - 2 regional landfills
  - no separate collection
  - little recycling
  - strong role JSC's

JSC	Collection	Transfer	Landfill
Hebron	+	-	-
Bethlehem	+	-	-
Jericho	+	-	+
Ramallah	+	+	-
N&NW Jerusalem	+	-	-
NE&SE Jerusalem	+	+	-
Salfit	+	-	-
Jenin	+	+	+
Nablus	+	+	-
Tubas	+	+	-
Qalqelia	+	+	-
Tulkarem	+	+	-
Hebron & Bethlehem	-	+	+

WASTE TO ENERGY OPTIONS FOR THE WEST BANK, PALESTINE

CURRENT SITUATION: WASTE MANAGEMENT

- landfill capacities

Landfill	Zahret al Fenjan, Jenin	Al Menya, Bethlehem	Total
Total surface in ownership (hectares)	24	26,5	50,5
In use for facilities (hectares)	3	3	6
Presently in use as landfill (hectares)	9	10	19
Average height of landfilled waste body (m)	40	20	60
Already landfilled on this area (mln tons)	2,8	1,5	4,3
Remaining capacity on this area (mln tons)	0,8	0,5	1,3
Potential capacity to be developed (mln tons)	4,8	2,7	7,5
Daily quantity delivered at landfill (tons)	1100	900	2000
Remaining lifespan (years)	13,9	9,7	12,1

- in crisis?
  - "in crisis" might not be true
  - actual capacity is low but potential is good
  - serious problems with GHG emissions, odour and leachate
  - but nothing that can't be solved
  - investments and planning needed on short term

WASTE TO ENERGY OPTIONS FOR THE WEST BANK, PALESTINE

CURRENT SITUATION: WASTE MANAGEMENT

- costs

	NIS		Euro	
collection	50-150	per ton	12-35	per ton
transfer when applicable	10-60	per ton	2,50-14	per ton
sanitary landfill	30-33	per ton	7-8	per ton
total costs	80-250	per ton	20-60	per ton
SWM fee	12-30	per hh.month	2,80-7	per hh.month

- total market around 120 mln NIS

- one family produces 1,3 ton/yr
- this would need €50/yr
- and the fee is ± the same

- affordability
  - imposed waste-fees could cover costs
  - but actual fee-payments are low
  - although payment by electricity bill
  - imposed fees are around 1% family budget ➡ affordable

WASTE TO ENERGY OPTIONS FOR THE WEST BANK, PALESTINE

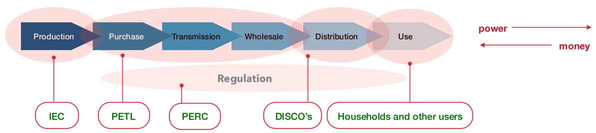
CURRENT SITUATION: ENERGY PRODUCTION AND DISTRIBUTION

- production and consumption
  - electricity consumption 4500 GWh with peak at 930 MW
  - growth 3,5% per year, 150 GWh per year
  - capacity 830 MW, 98% supplied by IEC
  - domestic production: 22 MW solar PV
  - renewable target: 130 MW in 2020 and 500 MW in 2030
  - of this 10% by biomass and biogas

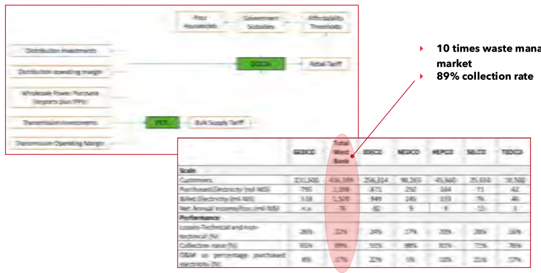
- distribution

CURRENT SITUATION: ENERGY PRODUCTION AND DISTRIBUTION

- organisation



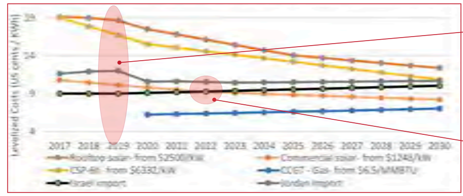
- cash flows



- 10 times waste management market
- 89% collection rate

CURRENT SITUATION: ENERGY PRODUCTION AND DISTRIBUTION

- KWh costs



- IEC at$ 0,09/KWh
- PV price going down
- PV break even with Israel import

- investments

- $ 1300/KW
- $ 760 for 1 MWh/year
- $ 4000/KW

CURRENT SITUATION: IMPLICATIONS

- low land availability
- limited water availability
- no demand for heat
- waste going from yearly 750.000 towards 1.200.000 tons in 15 years
- composition: 50% organics and 9 MJ/kg
- 100% coverage of waste collection
- available centralisation enhances economy of scale
- important role of transfer stations
- landfill capacity sufficient for 10 years
- but imminent problem if investments are not started up
- price reference level for landfills: gate fee of 35 NIS or € 8,50 per ton
- high expectations of 10-15 MW from waste in 2020
- no experience available in operating complex incineration/steam plants
- limited feed-in capacities of produced electricity
- price reference level for feeding in electricity: 7-8 $ cents per kWh

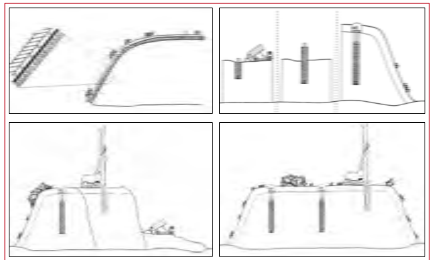
DESCRIPTION OF OPTIONS:

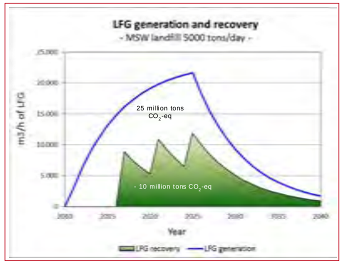
Obvious options
- enhanced landfill gas extraction
- direct incineration of bulk waste
- anaerobic digestion of organic waste

Non-energy reference option
- composting of organic waste

Discarded options
- gasification and pyrolysis of bulk waste
- high efficiency incineration
- biocell landfilling

DESCRIPTION OF OPTIONS: ENHANCED LANDFILL GAS EXTRACTION





- build up vertically
- apply cover as soon as possible
- drill extraction holes as soon as possible
- start extraction and flaring as soon as possible

- GHG effect CH_4 28 times that of CO_2
- losses due to delayed construction and losses during extraction
- convert CH_4 to CO_2 by electrification
- or at least by flaring

DESCRIPTION OF OPTIONS: ENHANCED LANDFILL GAS EXTRACTION

Production and potential

- full utilisation of landfill capacity
- Yatta landfill not included
- efficiencies from extraction, engine capacities and engine uptimes

Gas collection in m^3/hr	Zahret al Fenjan, Jenin	Al Menya, Bethlehem	Total gas collection	Potential for electricity production (kW)
gas production in 2018	1200	500	1700	4072
gas production in 2020	1300	700	2000	4790
gas production in 2025	1600	1300	2900	6946
gas production in 2030	1600	1700	3300	7904
gas production in 2035	1300	2000	3300	7904
gas production in 2040	800	1700	2500	5988
gas production in 2045	400	1500	1900	4551

Capex and opex

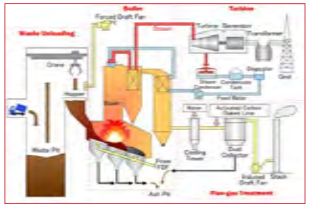
- attribution of landfill capping and extraction

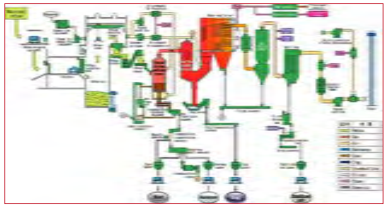
capex and opex	costs
landfill capping (€/ha)	350.000
investment in gas-collection and e-production (€/ha of capped landfill)	200.000
opex per landfill (€/year)	300.000

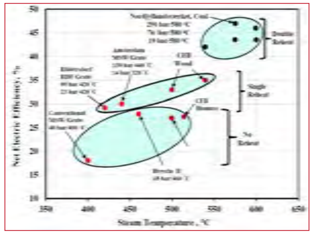
GHG emissions

- no preventive measures and extraction: 110.000 tons of CO_2 equivalents per year (25.000 cars)
- capping, collection and flaring leads to 68% reduction
- additional electrification leads to an additional 3% reduction

DESCRIPTION OF OPTIONS: DIRECT INCINERATION



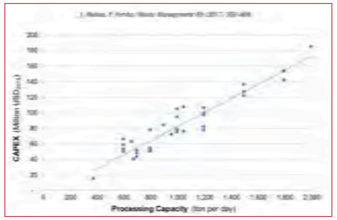


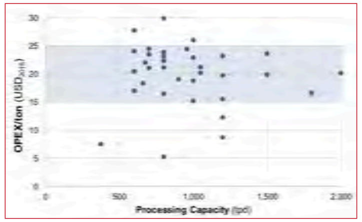


Technical and environmental

- conventional but still complex technology
- needs technical infrastructure, HR and "biotope"
- no Combined Heat Power options
- efficiencies above 20% only with availability of cooling water and hightech environment
- still 25% to be landfilled
- long period needed for preparation
- strong positive effects on GHG emissions

DESCRIPTION OF OPTIONS: DIRECT INCINERATION





Financial aspects

- Chinese installation investments: $230 per ton-year
- EU installations more like $900 per ton-year
- big differences in emissions
- differences in technical lifetime not yet known
- reference Ethiopia: $310 per ton-year
- assumption here: € 110 mln for 300.000 ton/yr
- opex of €20 per ton

DESCRIPTION OF OPTIONS: ANAEROBIC DIGESTION

Technical and environmental aspects

- produces gas and compost
- needs separate collection of biowaste
- co-treatment with market and agricultural waste
- long time needed for preparation separate collection
- anaerobic degradation leading to biogas
- 70 m³ of biogas (60% methane) per ton input
- 0,4 ton compost per ton input
- strong effect on reduction of GHG emissions but …
- separate collection never 100% for organic waste

Financial aspects

- economy of scale
- minimum capacity: 30.000 tons per year
- investment: € 23 mln for 50.000 t/yr, including simple composting
- opex: €27 per ton organic waste input
- separate collection costs €10 per ton MSW or €20 per ton of organic waste

WASTE TO ENERGY OPTIONS FOR THE WEST BANK, PALESTINE

DESCRIPTION OF OPTIONS: COMPOSTING

Comparison of Composting Technologies

	Investment	Maintenance	Space	Time	Labor
Windrow Composting	●	●	●●●●●	●●●	●●●●●
Passively Aerated W.	●●	●●	●●●●●	●●●	●●
Forced Aerated W.	●●●●	●●●●	●●●●	●	●●
In-Vessel	●●●●●	●●●●●	●●●	●	●●
Bin Composting	●●●	●●	●●●	●●●●●	●●

Technical and environmental aspects

- simple and cheap technology for organic waste
- no energy production
- aiming at compost for agricultural use
- therefore: separate collection needed
- implementation time for separate collection can be used for pre-treatment for landfill
- strong effect on GHG reduction

Financial aspects

- simple windrow composting considered
- low economy of scale
- 50.000 tons/year needs € 3 mln investments
- opex around €10 per ton input organic waste
- also here costs of separate collection can be attributed

WASTE TO ENERGY OPTIONS FOR THE WEST BANK, PALESTINE

ASSESSMENT: CRITERIA

- technical
  - complexity
  - flexibility
  - scale
  - knowledge
  - connections
- financial
  - needed capital
  - needed gate fee
- landfill consequences
  - reduction landfill use
- environmental/social
  - reduction GHG
  - waste hierarchy effects
  - public acceptance
- energy
  - production potential
  - LCOE
- other
  - planning
  - institutional effects
  - risks

- at maximum implementation
- cashflow analyses, 15 year period
- full financing at 8% interest
- gate fee calculated for reaching cumulative cash flow at zero in 10 years at €0,07/kWh

- at maximum implementation
- with current situation as reference

- at maximum implementation
- LCOE calculated at discounting ratio 8%

- time needed for implementation

WASTE TO ENERGY OPTIONS FOR THE WEST BANK, PALESTINE

ASSESSMENT: RESULTS

Categorie	Aspects	landfill gas extraction	direct incineration	anaerobic digestion	composting
Technical	Complexity	low	very complex	some complexity	very simple
	Flexibility	very high	no flexibility	some flexibility	very flexible
	Minimum scale	n.a.	> 300.000 tons/yr	> 30.000 tons/yr	> 30.000 tons/yr
	Knowledge c.a.	low	high level	certain level	low level
	Connections	< 10 MW	> 10 MW	< 10 MW	n.a.
Financial	Capital needed	€ 30 mln	€ 300 mln	€ 150 mln	€ 25 mln
	Gatefee	€ 0,50 per ton	€ 50 per ton	€ 105 per ton	€ 35 per ton
Landfill	Prevention use	0%	75%	50%	50%
Environment/social	GHG emission reduction	80.000 tons of CO_2 per year	110.000 tons of CO_2 per year	90.000 tons of CO_2 per year	80.000 tons of CO_2 per year
	Waste hierarchy effect	no effect	negative	positive	positive
	Public acceptance	high	negative	no effects	no effects
Energy	Production potential	40 GWH/yr	350 GWH/yr	40 GWH/yr	0
	LCOE	€ 69/MWh	€ 150/MWh	€ 840/MWh	n.a.
Other	Planning	2 years	5 years	2-5 years	1-5 years
	Institutions	no effects	strong effect	some effects	no effects
	Risks	no risks	higher risks	some risks	no risks

At max. utilisation

- lowest price
- cheap
- fast
- most needed

- highest potential
- highest investments
- most complex

- high investments
- highest price

- no energy
- lowest investments
- fast option

ASSESSMENT: SCENARIO'S

- the effects of combining landfill gas extraction and composting

	combining options 1 and 4
effect on landfill capacity	goes from 10 to 15-20 years
effect on GHG emissions	reduction of 80.000 tons CO_2/year
effect on energy production	production of 30-35 GWh/year
effect on overall SWM costs	extra costs €10-15 per ton

- the effects on lifespan of current landfill capacity

	additional years above current 10 years
start direct incineration in 2023	2-3 years extra
start anaerobic digestion in 2022	4-5 years extra
start composting in 2020	6-7 years extra

- compare direct incineration to PV

	direct incineration	PV utility scale
capex (€ per installed MWh/yr)	860	750
LCOE (€ cents per KWh)	15	8,5
production prophile	continuous	only daytime
implementation prophile	one large step	multiple small steps
land use	low	high
energy security	??	high

- what if investments in direct incineration would be granted

	LCOE (€ cents per KWh)
full financing	15
50% granting	10,5
100% granting	5,5

ASSESSMENT: QUESTIONS AND ANSWERS

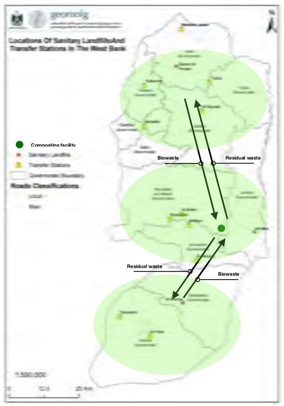
- can we do without landfills?
  - no, there's no scenario without residues.
- what other options for reducing landfill use do we have?
  - focus on construction and demolition waste.
  - prepare for separate collection
- what other options for combining waste and energy?
  - use landfill slopes for PV
  - prepare separate collection of wood waste for dedicated incinerator

ASSESSMENT: OTHER

- what are institutional effects?

Responsibilities	landfill gas extraction	composting	anaerobic digestion	incineration
financing	JSC's, supported by donors	JSC's, supported by donors	JSC's, supported by donors	outsourced as long term concession for financing, design, construction and operation.
design	outsourced to specialised companies	design can be done by the JSC's.	outsourcing design, construction and operation (and possibly also financing) to private operators	
construction	outsourced to contractors with adequate references.	procured based on JSC design.		
operation and maintenance	outsourced to contractors with adequate references.	JSC's or outsourced		

- what are the best locations
  - composting and anaerobic digestion could be run on landfills or more to the center (Ramallah or Jericho)
  - incineration should be located near access to water (for steam production) and high voltage grid



CONCLUSIONS

- implement landfill capping and gas extraction as soon as possible
- weigh and discuss all aspects of direct incineration within Palestinian context
- when not choosing incineration, prepare for introduction of separate collection and composting
- install available landfill capacity as soon as possible

TECHNICAL PROPOSAL

PART OF THE NORTHERN CONSORTIUM JENIN PROPOSAL

Table of Contents

Reference to RFB

This document is an integral part of the proposal of Northern Consortium, in response to

- "*Request for Bids International Competitive Bidding. Design, Build, Own and Operate (DBOO) Waste to Energy Incineration Plant at Zahrat Al Finjan Landfill - Jenin Governorate*" (Project No: MOLG2020-1/20). Document name: '*WTE RFB (REVISEDC.pdf)*'
- "*Draft Concession Agreement - For the supply of electricity from Waste Incineration Plant at Zahrat Al Finjan Landfill"* (MoLG WTEC/2020). Document name: '*WTE Concession Agreement.C.pdf*'
- "*Feasibility Study Report – Waste to Energy options for the West Bank, Palestine*", dated November 18th, 2018.
- *"Response to Bidders' Requests for Clarification"*. Document name: *'WTE All Answers final.pdf'*

This document will respond to the following requirements:

RFB reference	Requirement description	Provided in
	Introduction	Chapter 1
Appendix V-a	Methodology statement	Chapter 2
Appendix V-b	Process Flow Chart and Material Balance Statement	Chapter 3
Appendix V-c	Resource Utilization Statement	Chapter 4
Appendix V-d	Area Allocation Statement	Chapter 5
Appendix V-e	Operations and Maintenance Scheme	Chapter 6
Appendix V-f	Time Schedule	Chapter 7
Appendix V-g	EHS Policy and Practise	Chapter 8

In various chapters, reference is made to "The Reference Plant" (Appendix A). This document contains an in-depth description of various aspects of the Amsterdam plant.

1 Introduction

Reducing the need for landfills by establishing High-Efficiency Waste-to-Energy (HE WTE) plants plays an important role in tackling climate change globally and creating healthy societies locally. The Northern Consortium intends to closely work together with MoLG, JSC and local communities develop and operate a state of the art and most efficient WTE facility for at least 25 years. This will hugely reduce dependency on the Zahrat Al Finjan Landfill capacity and delivering 24/7 baseload native electricity to the Palestine Territories, reducing the high dependency on power imports. Our Northern Consortium consists of technology providers who are experts in their fields and have a proven track-record of designing, constructing and operating WTE and other energy infrastructure plants on various continents. The technical knowledge is combined with the best and most relevant local knowledge available.

As part of the *Request for Bids ICB for Waste to Energy Incineration Plant at Zahrat Al Finjan Landfill- Jenin Governorate* (Project No. MOLG2020-1/20), the “RFB”, MoLG requests our Technical Proposal for the design, construction, financing, operation and maintenance of a plant capable to handle a minimum of 1,200 tons of waste (MSW) per day, as per RFB Section 3.3.1.

We propose to construct a 1200 tons per day High Efficiency Waste-to-Energy plant based on the robust and proven *moving grate incineration* technology. A higher capacity may be opted for during the feasibility study phase to accommodate future increase of waste production if necessary and will further increase the energy autonomy of Palestine. The actual size will be determined during the feasibility phase. This technology is already successfully operational since 2007 at the Amsterdam High Efficiency WTE Plant in the Netherlands. Our solution will produce 30-60% more electricity, it will have the lowest CO2 emissions per MWh, and the highest waste recovery rate when compared to conventional WTE technologies.

Our High Efficiency WTE concept covers the whole system: from waste acceptance to treatment (including incineration, water-steam cycle and flue gas treatment) and electricity production:

Gross output	43-45 MW (@9000 kJ/kg)
Efficiency	31-33% gross (~28-30% nett)
Availability	> 90%
Diversion from landfill	> 90% (depending local regulations on bottom ash)
Emission standard	EUdir2010/75 updated BREF 2019
Type	Moving grate incinerator

The maximization of value from the waste through the higher electricity production and lower emissions, will allow the High-Efficiency WTE plant to be potentially eligible for carbon credit subsidies, well above alternatives with lower power output per ton of waste.

The High Efficiency WTE plant proposed by the Northern Consortium is graded as unique according to DNV-GL (ref. Appendix B). It is the beyond "best available technology" (BAT) from an OECD country. It has proven to function robustly and sustainably for more than 10 years at AEB Amsterdam (The Netherlands). The High Efficiency Technology is elaborated on in Appendix A The Reference Plant, chapter 1.6: *The Clean and Safe Sink-Solution*.

Northern Consortium partners are passionate about Urban Clean-up and extremely motivated to support the JSC and MoLG with the powerful combination of best-in-class technology and an attractive business model. Together, we want to turn the growing volume of residual waste into clean energy and local jobs, while kickstarting a circular economy in Palestine sustainably (see also Chapter 9. Additional Options)

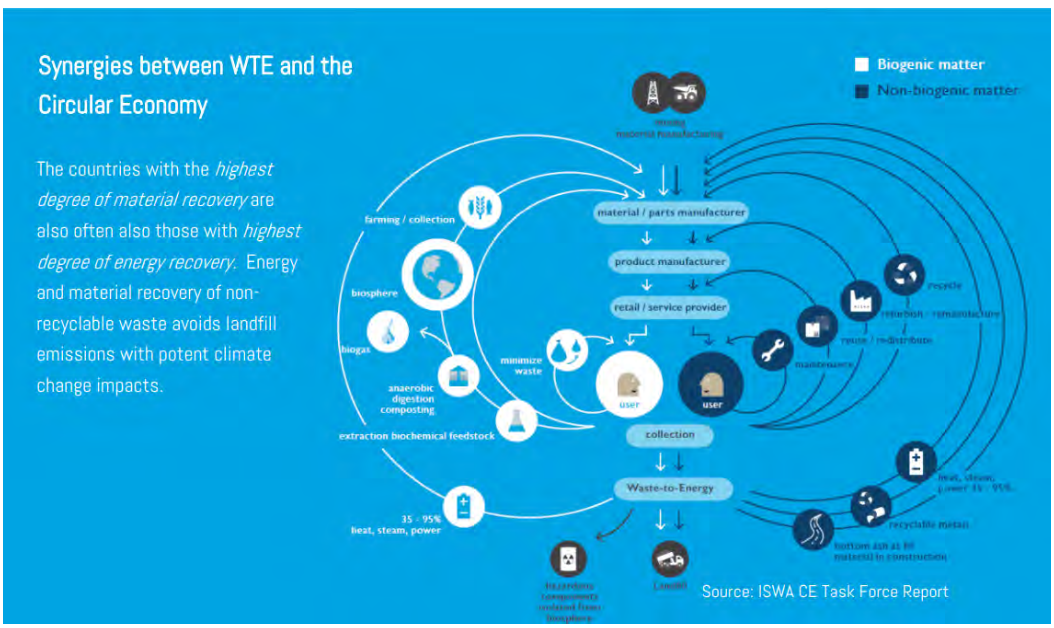


Figure 1 The Circular Economy

Overall, the Project proposed will create:

1. Clean, reliable energy, financially attractive for the shareholders with 30-60% higher electricity production than other conventional WTE alternatives.
2. Low GHG emissions with our most environmentally friendly solution, following all requirements from the perspective of sustainability, health and safety.
3. Local employment associated to a new standard for waste management in Palestine as the first of its kind WTE plant, a lighthouse project for Jenin.

Northern Consortium

2 Methodology statement

2.1 Specific Requirements according to RFB

"The Bidder shall provide a methodology statement, which broadly sets out the approach to the Project. The methodology statement shall include the Bidder's appreciation of the Project, the sequencing of activities to be performed, the facilities to be provided, design standards. The methodology shall detail the financial proposal including the financial plan with proposed financing resources, the financial model, and the cashflow.

The methodology statement should clearly demonstrate the compliance of the approach to be adopted by the Bidder for the implementation of the Project to the minimum requirements set out in the Concession Agreement."

Scoring Parameters

Criteria	Parameters	Paragraph	Weight
Methodology Statement	- Appreciation of the Project	2.2	20 / 100
	- Project sequencing	2.3	
	- Facilities to be provided, including plant capacity and efficiency incl. Preliminary design	2.4	
	- Design standards	2.5	
	- Basis for calculations incl. Proposed Financing Sources - Financial plan - Financial model - Cashflow	2.6	

2.2 Appreciation of the project

The Joint Service Council (JSC) for Solid Waste Management in Jenin operates the sanitary landfill at Zahrat Al Finjan Landfill since 2005 and receives municipal waste from 5 Governorates in the Northern part of the West-Bank in Palestine. The Ministry of Local Government (MoLG) decided that the JSC should develop a more advanced waste treatment system where municipal solid waste (MSW) received at the landfill is converted it to energy through a Waste-to-Energy (WTE) incineration facility. Currently, the JSC receives over 400,000 tons of municipal waste (MSW) per year, a quantity that has been constantly growing over the past 11 years.

WTE plants burn household and similar waste that could not be prevented or recycled. From this waste incineration process the plants generate energy in the form of electricity, steam or hot water. The electricity is fed into the grid and distributed to the end-users; the hot water, depending on local infrastructure can be sent to a nearby district heating (or cooling) network to heat (or cool) homes, hospitals, offices etc., and the steam can be used by the nearby industry in their production processes. Waste-to-Energy is a hygienic method of treating waste, reducing its volume by about 90%. Modern Waste-to-Energy plants built in Europe are clean and safe, meeting the strictest emission limit values placed on any industry in the EU.

During the RFB process, MoLG unambiguously expressed their interest in minimizing the amount of waste that is currently accumulating at the existing sanitary landfill with several challenges for society and the environment. The creation of a modern and efficient solid waste incineration plant will ensure a long-term sustainable approach to waste management in the region. For the local communities surrounding the facilities important topics are reduction of odour nuisance and water pollution problems and at the same time creation of jobs in this new line of business. It is in the interest of MoLG to look for solutions that *maximize the energy output* per ton of waste, at the best price for the electricity delivered and with minimal impact on the environment, while serving the local communities in the best way through the project's lifetime.

This first plant needs to be developed adjacent to the existing landfill area. It shall comply with the Technical Requirements, the Design and Certification Procedure and the Government's Review Procedure as per the Concession Agreement provided. JSC will be responsible for municipal waste delivery to the weighbridge of the new plant. The Concessionaire shall operate the Plant for a period of 25 years and sell the electricity to PETL. Our proposed solution will generate well above the required 25MW of electrical energy, while we can divert more than 90% of the waste from needing depositing at the landfill instead turning the waste into energy and new materials. The expected and proven availability will easily exceed the required 80%, based on the performance of >92% in the reference plant over the past ten years.

This method statement will address the project sequence, design principles and standards as well as a preliminary financial assessment taking the Technical Requirements and all of the above into consideration.

2.3 Project Sequencing

In order to develop a HE waste-to-energy facility from idea to operation, the following development stages and milestones are defined, based on Front-End Loading[1] (FEL):

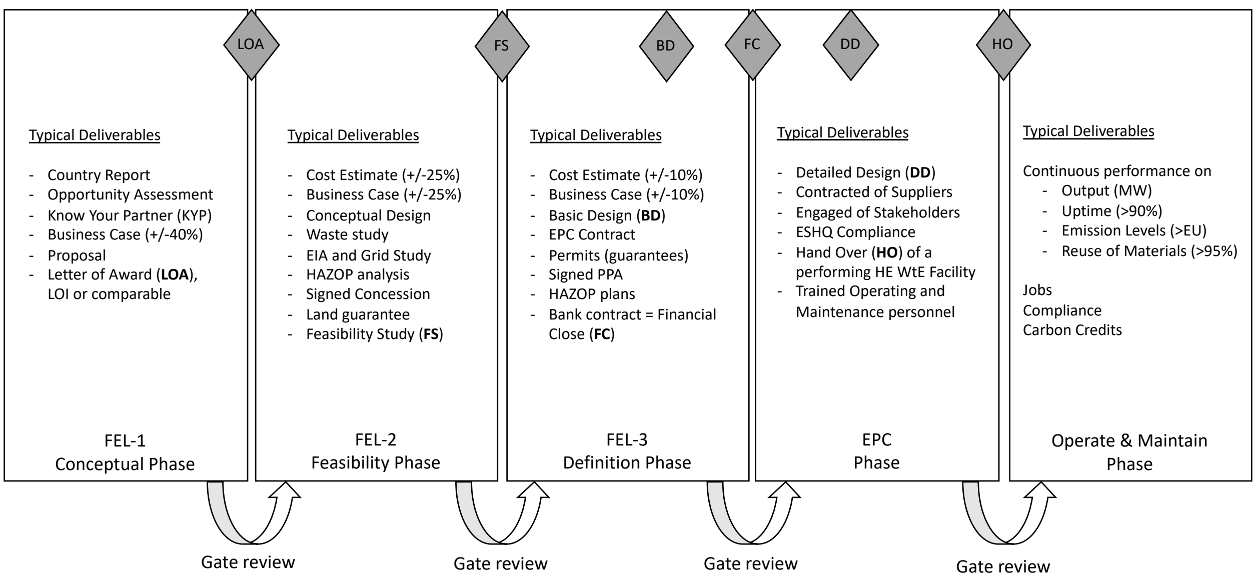


Figure 2 Gate Process

1. <u>Conceptual phase (FEL-1).</u> In this phase, an opportunity is investigated. Also, partner- and relationships are built. Governmental bidding procedures are part of this phase. The conceptual design of the intended plant and its basic configurations will be determined.
2. <u>Feasibility Phase (FEL-2)</u>. This phase determines whether the project is technical, economical & environmental feasible for involved parties. In this phase the conceptual design will be assessed and approved.
3. <u>Definition Phase (FEL-3)</u>. In this phase, the exact 'definition' of the project is established, an EPC will be selected, and financing is secured. The conceptual design will be translated in a basic engineering package (BE) and all design parameters will be fixed for the detailed engineering (DE) phase. This phase will result in Financial Close (FC) for the project.

[1] https://en.wikipedia.org/wiki/Front-end_loading

4. EPC Phase. This phase is where the facility is designed in detail, procurement of parts from suppliers will be done, and the facility will be constructed. The plant will have its start-up and guarantee test runs, before hand over (HO) at commercial operation date (COD).
5. Operate and Maintain Phase. In this phase, the plant will convert waste to energy, following the PPA, Waste Concession and other agreements. This includes performance on electrical output (MW), availability, emission levels and compliance with regulations, etc.

To control the risks during these development stages, the Northern Consortium will manage its development process with the 'gate process'[2] as depicted above. In order to pass to a next phase, prescribed deliverables have to be approved through a 'gate review' and go through external checks by the authorities amongst others.

2.4 Facilities to be provided, including plant capacity and efficiency

The first step towards a holistic sustainable waste management system for Jenin and subject of this bid is a Waste to Energy plant to convert all residual waste streams into energy.

Figure 3 Impression of High Efficiency Technology/4th generation WTE

Our proposed High Efficiency WTE plant can handle a minimum of 1,200 tons per day (TPD) and allows for potential reduction of already accumulated waste and be prepared for further growth in waste volumes (the exact size may have to be adjusted during the feasibility phase when all assumptions sand information will be checked again).

The entire system shall include receiving area, storage/bunker, incineration/boiler, turbine, double-dry flue gas treatment, water-steam cycle, offices, visitor centre, and connection to the local power grid that complies with local requirements and fulfils international standards for waste to energy plants and their emissions.

[2] Gate process and gate criteria available on request

During the feasibility and definition phase, critical topics such as:

1) usage of water, a scarce resource in Palestine;
2) the connection to the local electricity grid, that is likely to need an upgrade for receiving the power of the new WTE plant; and
3) the remaining partly inert fractions of the waste after incineration, which can be cleaned and reused for construction materials plus the hazardous fraction from Flue Gas cleaning which will be immobilized and safely stored, will be addressed.
4) Temporary storage for waste to overcome delivering issues.

According to the Feasibility Study Report which was shared as part of the RFB and based on our own local knowledge, the current grid connection may not be suited to receive our expected power output. We will verify this at the start of our project and if needed modify the current substation in order to accommodate the export of ~40 MW to the grid. If this is not feasible, we will find together with PETL another location to feed in. Additional cost is accounted for upgrading the local substation. If it will be necessary to find another feed in location additional cost allocated but with a high uncertainty due to lack of information.

A side view of the proposed plant structure is presented below, and in Appendix C in larger format.

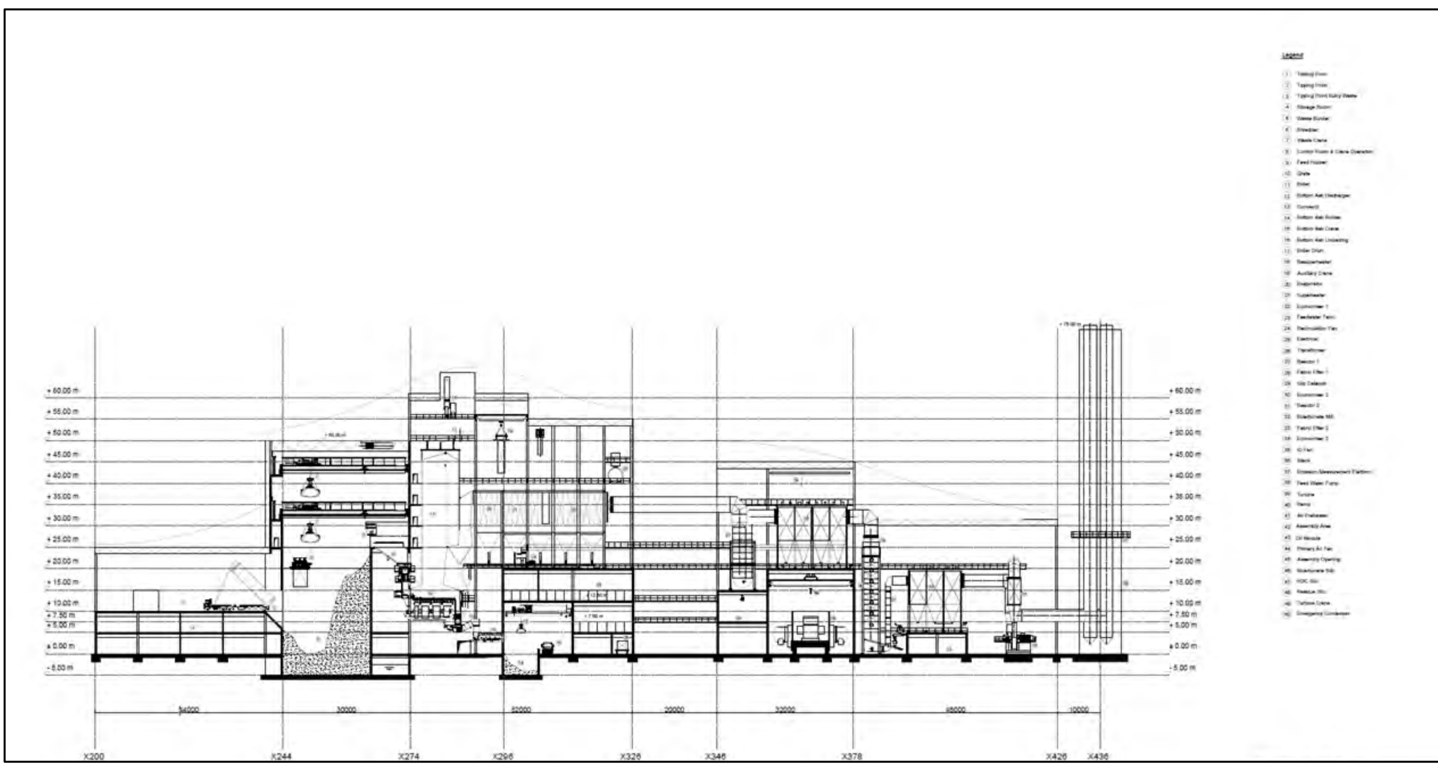


Figure 4 Layout of the proposed WTE plant with double dry FGT

Northern Consortium

Key features of the facility

The Project consists of the following key features:

1. Waste Reception & storage
    - Weighing bridge
    - Intermediate storage facility outside the plant
    - A bunker for a minimum of 5 days storage
2. Steam & Energy production
    - Chute
    - Dosing and grate
    - Boiler including SNCR (selective non-catalytic reduction)
    - Steam-water cycle
    - Turbine Reheater
    - Condenser
    - Air-cooled condenser
3. Flue Gas Treatment
    - FGT system
    - Reactor for Bi-carbonate and active cokes injection
    - Bag-filter
    - SCR for Denox (optional, to be determined in basic engineering)
    - Reactor for lime injection (extra cokes injection optional)
    - FGT heat exchanger for extra heat recovery and possible water production (optional)
4. Utilities
    - Chemical storage facilities
    - EM generator
    - Firefighting system
    - LAB facility
    - Other: compressed air, HVAC, DEMI water installation

Waste storage for plant operation continuation

In our HE WTE concept for this Project, a waste acceptance area and weighing bridges for incoming and outgoing waste are included. The plant will have a bunker facility for storage of the waste. In the bunker the waste will be mixed dried and fed into the chute of the incinerator. The bunker will have a capacity to store waste for 5-7 days to overcome disruption of waste delivery, weekends, festivities and holidays. As an additional contingency for longer durations of insufficient supply of MSW, we propose to designate an emergency storage site at the landfill for long-term storage of baled waste. This will be decided on in collaboration with the JSC.

Plant capacity and efficiency

Capacity	1200	Tons/Day
2 lines	665	T/D @ 90% availability
LHV	9000	MJ/T
Rated output gross	43-45	MW @1200 T/D throughput
Targeted Efficiency gross	~ 31-33	%

2.5 Design standards

The proposed Project will be based on the reference plant[3] at AEB in Amsterdam, where the 4th generation WTE plant was realized in 2007 and has been operating successfully ever since. The 4th generation is also known as the High Efficiency WTE plant, which combines the HE technology and HE philosophy. The HE philosophy is about designing for **maximum recovery of materials and energy**, following a design aimed at the lowest Total Cost of Ownership (TCO). Regarding emissions to the environment the ALARA principle (*As Low As Reasonable Achievable*) is used, following the European standards and out-performing these where reasonably possible.

Above all, Safety has the highest priority throughout the design process and operational execution of the Project. Safety First!

Our design will be compliant with the following international QA/QC standards, following the Quality Assurance Management Plan QAMP guidelines: ANSI, ASME ISO-9712. To ensure the integrity of the installation the appropriate materials, testing and welding instructions will be provided. This way optimization in availability and lifetime can be reached from the perspective of total cost of ownership (TCO).

Next to these international guidelines and high-quality design principles, we will follow local regulations and practices, such as local economic and social development planning, local government planning and city construction principles, and follow the Palestinian policies for environmental protection besides adhering to the EU standards.

The following design principles are the basis for Jenin WTE project:

1. Choose energy savings, usage of advanced and reliable equipment with a higher level of mechanization and automation to improve the production efficiency to reduce labour intensity, improve the working environment, and assure safe production.

[3] See Appendix A. The Reference Plant for more details on the High Efficiency technology and maximization of recovery

2. Protect the environment and prevent secondary pollution. This means that the emissions of pollutants can meet the ultra-clean emissions of the Netherlands standards, which are **more stringent than the EU2010 directive**. We use the Best Available Technology (BAT) to reach beyond the minimum standard of EU directive EU2010/75 *updated BREF 2019*, following ALARA principal.
3. Rational utilization of land, giving enough space for the key components in the production process, reduced land occupancy, buildings centralized as much as possible, keep more landscaping and gardening, which does not only beautify the environment but also can reduce the ambient noise.
4. Apply system design to save and re-use water, internal electricity use, strengthen energy reuse and avoid the waste of resources.
5. Make connections to the available local waste infrastructure, water connections, sewage connection, power connections and logistics early on to integrate the Project smoothly into the existing infrastructure and procedures. This will be done in close cooperation with the local government and other stakeholders. The project will only be responsible for all these items within the battery limits.
6. Plant construction will prioritize modern style design, being concise and lively, while at the same time having local characteristics displaying environmental harmony and it will have an identifiable signature.

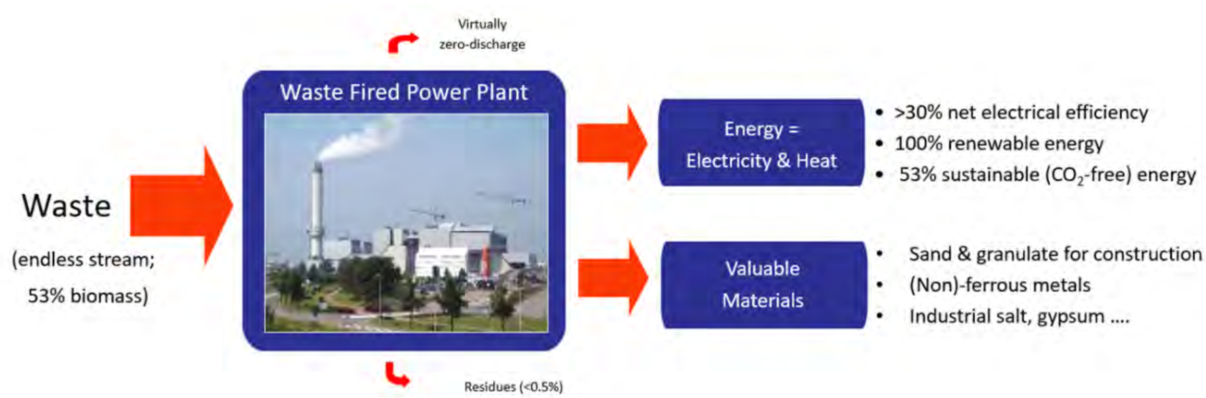


Figure 5 - 4th Generation: Waste to Power in a nutshell

2.6 Basis for Calculations

All basis for calculations, including Proposed Financing Sources, Financial plan and Financial model, are provided in Appendix M.

Northern Consortium

3 Process Flow Chart and Material Balance Statement

3.1 Specific Requirements according to RFB

"The Bidder shall provide a process flow chart and a material balance statement setting out the activities and the outputs at each stage."

Scoring Parameters

Criteria	Parameters	Paragraph	Weight
Methodology Statement	- Process flow chart	3.2	15 / 100
	- Material balance statement	3.3	
	- Supporting calculations and assumptions	3.4	
	- Life cycle cost analysis	3.5	

3.2 Process flow chart

The process flow chart of the proposed 1200TPD HE WTE plant is provided below.

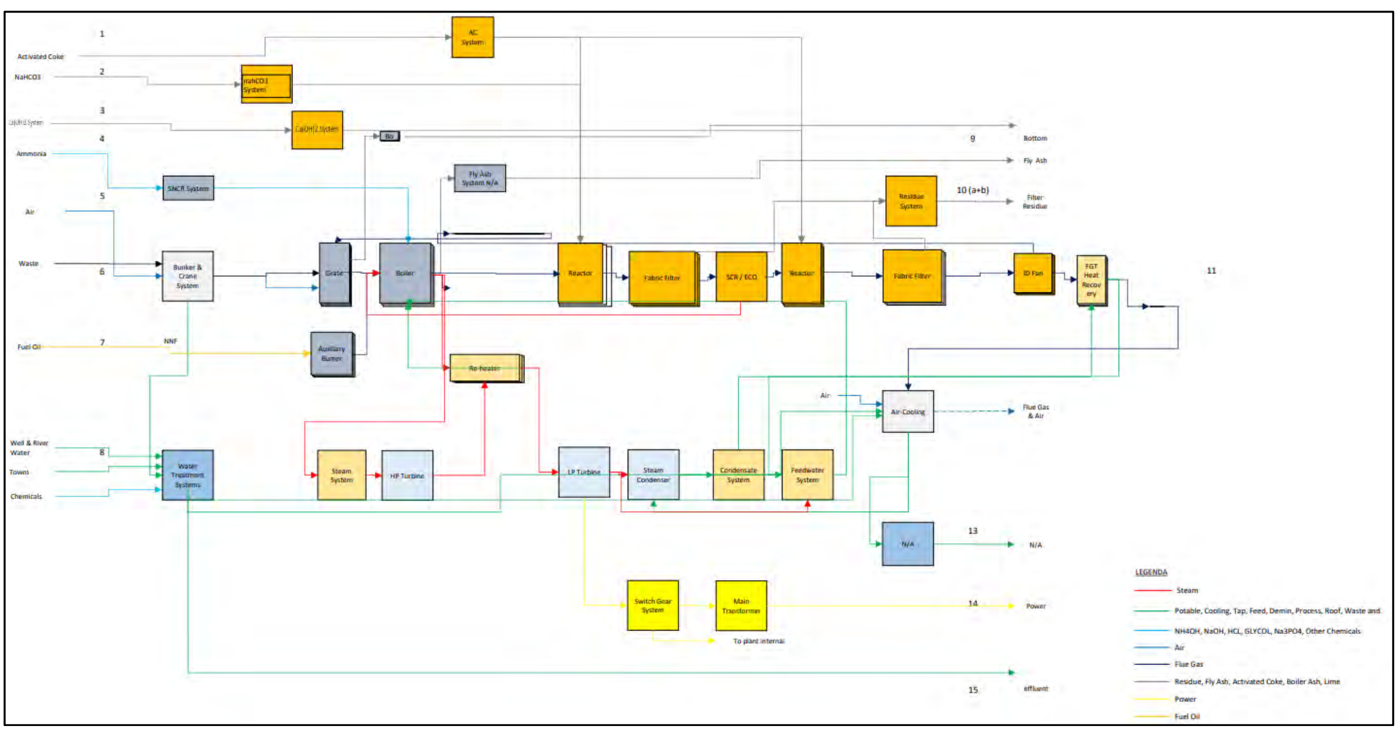


Figure 6 Flow Diagram

For a larger version of the block flow diagram corresponding to the mass balance see Appendix D.

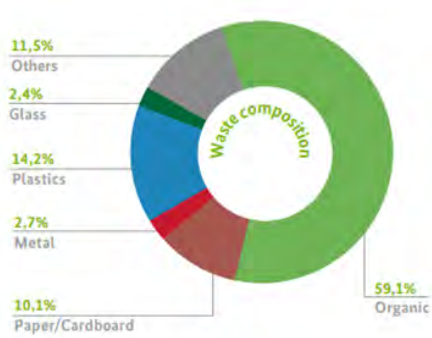
Flow No	1	2	3	4	5	6
Medium	Activated Code	NaHCO3	CA(OH)2	Ammonia Water	Air	Waste
Mass/Volume	60 kg/h	750 kgh	76 kg/h	200 kg/h	243,300 Nm3/h	69,2 Mg/h
Additional Information			90% pure	25% aq.		7-9 MJ/kg

7	8	9	10a	10b	11	13	14	15
aux fuel	Towns Water	Bottom Ash	FF residue	Filter Residue	Flue Gas	Cooling Tower Effluent	Power	effluent
TBD	10 m3/h	8180 kg/h	1011 kg/h	143 kg/h	371,568 Nm3/h	0	41-45 Mwel	3 m3/h
		380 kg/h			60-95 Celsius	30 Celsius	11 kV/33KV	

Figure 7 Mass balance sheet for the proposed WTE plant in Jenin

3.3 Material balance statement

For the incineration plant we expect to receive 1200TPD of residual Mixed Solid Waste from JSC.



Following information from recent local waste characterization studies, we may expect the inert fraction to be between 15-18% as high estimate, but most likely between 13-15%. Actual inert fraction will be mainly depending on the type of collection, stages of waste treatment prior to the waste being sent to the plant and waste acceptation standards we will agree with the JSC. For our calculations we use 15%. It is not expected that there will be much free water nor a high moisture content in the waste. The waste characterization and the total ash content of the waste needs to be assessed in the first stage of the feasibility during the *waste composition study*.

Bottom ash residue:

Moving grate incinerators produce an inert fraction of 10-18% of the total waste input as residue product, also called bottom ash. Bottom ash contains valuable ferrous and non-ferrous material which may be recovered next to granulate. Bottom-ash can have some value after proper treatment which has to be feasible under local conditions.

Describing the process for extracting the value of the bottom ash: In a first sorting step the ferrous and non-ferrous will be separated using the sophisticated technology of Blue Phoenix Group[4] who will be a possible subcontractor to the project. After that, a cleaning process for the granulates and sand will be added, and in compliance with local regulations and leaching characteristics a suitable solution will be found for the reuse of this material.
If this will be found feasible up to 95-100% of this inert fraction can be reused. Which means that potentially less than 1% of the total waste input needs to be landfilled after treatment. This can have a huge impact on the capacity outlook for the sanitary landfill.
Figure 10 below depicts the valuable bottom ash resources after treatment and the options to recover these.

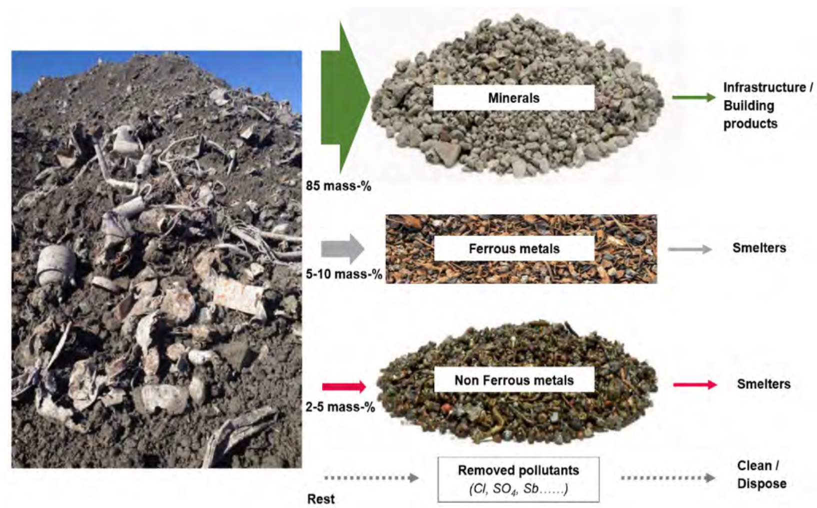


Figure 8 Possible Recovery Options from the Plants Bottom Ash

The feasibility of treatment options depends on local leaching circumstances and market conditions for granulate. If advanced treatment is not yet feasible, the bottom ash will be stabilized and securely stored in the existing landfill. Mapping out the options for bottom ash treatment will be part of the feasibility study.

FGT residue:
In the cleaning process of the flue gasses, calcium-bi-carbonate, calcium hydroxide and active coke is used to break down the toxic components in the flue gasses. In this process, hazardous salts will be formed and captured in the bag filters. This FGT residue needs to be immobilised and safely stored in secured landfills. The total production is within 1-2% of the total waste input depending on the composition of the waste.

[4] https://www.bluephoenix-group.com/

Northern Consortium

3.4 Supporting calculations and assumptions

For the projection below we conservatively assume the waste will have an inert fraction of 15% and an average LHV of 8 MJ/kg. We expect 1200TPD of mixed residual waste at the gate.

Total waste input		Total residues		
1200	Tons/Day	FGT residue	1,5-2%	7 - 9 kT/a
		Bottom ash	10-18%	44 kT/a - 79 kT/a
438.000	Tons/annum	Possible Bottom ash reused	95-100%	

3.5 Life cycle cost analysis

The Consortium will own and operate the facility in a DBOOT structure for at least 25 years. As mentioned in our design philosophy, the approach chosen is therefore from the perspective of lowest Total Cost of Ownership (TCO). This means that slightly higher investments may be done upfront in equipment, staff and preventive maintenance which will more than pay back in the longer run through increased reliability, availability and lower operational cost.

AWECT originated from the Waste to Energy company AEB-Amsterdam. AEB has more than 100 years of experience in developing and operating 4 generations Waste-to-Energy plants in the city of Amsterdam. This experience provides the necessary knowledge base to prescribe the right requirements to suppliers for all equipment which needs to be installed and maintained during the operating life of the plant.

These prescriptions will be part of the tender requirements for the suppliers and EPC company/companies who will construct the plant. So, besides the international QA/QC standards as mentioned in chapter 2.5, the extensive O&M experience of WTE plants will be used in the development of the proposed plant. As will mentioned in chapter 6.3, a major overhaul interval of 2 years is chosen following the lowest TCO considerations and is based on the experience of operating the reference plant in Amsterdam. This overhaul interval will demand specific high standard standards and requirements on materials and sustainability of the equipment. The reference plant in Amsterdam is working with the same 2-year interval successfully for over 10 years. All lessons learned from the reference plant will be used in the procurement requirements for this plant. Annually, 3% of the total capex is reserved to cover operational maintenance costs, and in addition 1% of total capex is reserved annually for major overhauls. This is accounted for in the business case and based on our Amsterdam experience where these numbers were found as an optimum. During operations, we will monitor the availability of the plant and maintenance costs considering safety and environmental impact, equally balanced.

Please refer to chapter **Error! Reference source not found.** for the projected cash flow statement.

4 Resource Utilization Statement

4.1 Specific Requirements according to RFB

"A statement indicating the procurement, deployment and utilization of the resources shall be provided. The statement shall include proposed organizational structure, employee deployment, equipment procurement and utilization, contracting activities, utilization of office and other facilities."

Scoring Parameters

Criteria	Parameters	Paragraph	Weight
Resource Utilization Statement	- Manpower deployment including CV's of senior staff	4.2	15 / 100
	- Equipment procurement and utilization	4.3	
	- Contracting activities	4.4	
	- Support Infrastructure	4.5	

4.2 Manpower deployment including CV's of senior staff

Manpower during all phases of the project will be provided on a 'best fit for the job' basis. Northern Consortium partners are extremely well positioned to arrange the best resources for project development and the subsequent operations of the facility. Our approach is outlined in the paragraphs below. We will comply with the requirements of local labour as per article 9.1 of the Concession Agreement. The presence of Koblenz and ITEC in our consortium, both firms with good relationships with local suppliers and workforce in the cities adjacent to Jenin, signifies our commitment to meet all the requirements set by the MOLG.

4.2.1 *Manpower during Project Execution*

In order to ensure the project will be managed successfully during all development phases (described in chapter 2.3), the project method[5] and organization will be expanded during the project development phases and will organically grow towards the O&M phase such that knowledge and skills developed will be firmly anchored in the organization. At the start of project execution (EPC phase), the project organization will be at full strength.

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[5] Project methodology based on input from international project standards (PMI/PMBOK & IPMA) as well as field experience from project managers and directors.

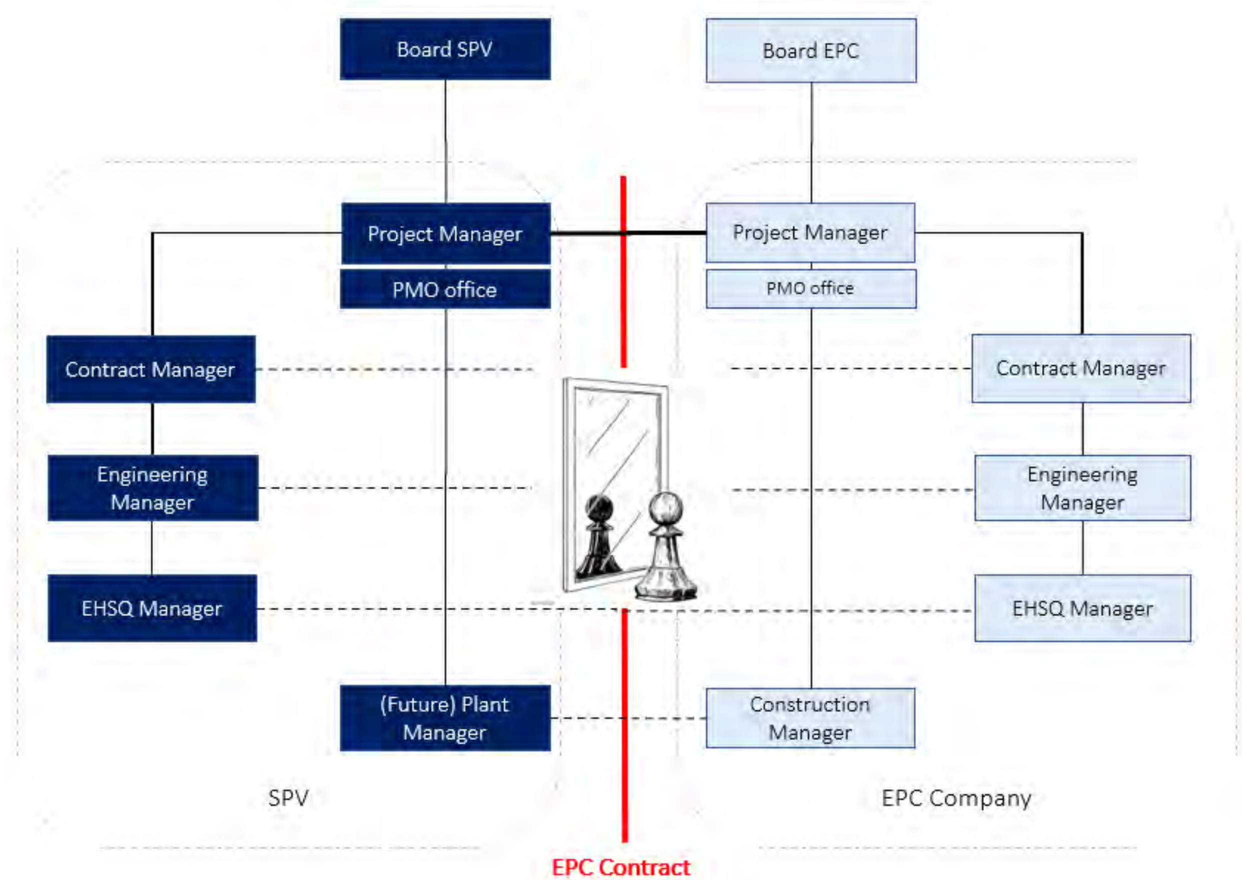

Figure 9 Mirrored Project Organization

The philosophy of the project organization itself, is based on three basic principles:

1. Separate supervision (SPV) and execution (EPC) while managing the contract, with 'mirrored' roles to make sure interaction and risk identification & mitigation are based on common expertise and knowledge. Profiles of senior staff roles are provided in Appendix E.
2. Create natural tension within project team by allocating aspects like time, costs, quality and scope (split), to different project roles. In this way, these interests are weighed within the project team, led by the project manager. The possible tension between various interests is therefore not obscured, but explicitly challenged.
3. Overall risk management approach is essential in the balance of interests. This will lead to decisions that achieve the best possible project result with the lowest overall project risk.

The total scope of work will be divided in separate lots, as provided below (1-9). A main EPC company to take overall responsibility of the project execution, will be selected during the Definition phase. Subsequent selection, contracting and deployment of sub-contractors and suppliers for the execution of the work itself, will be done by the EPC provider. The 'Main EPC' will provide a back-to-back guarantee to the SPV.

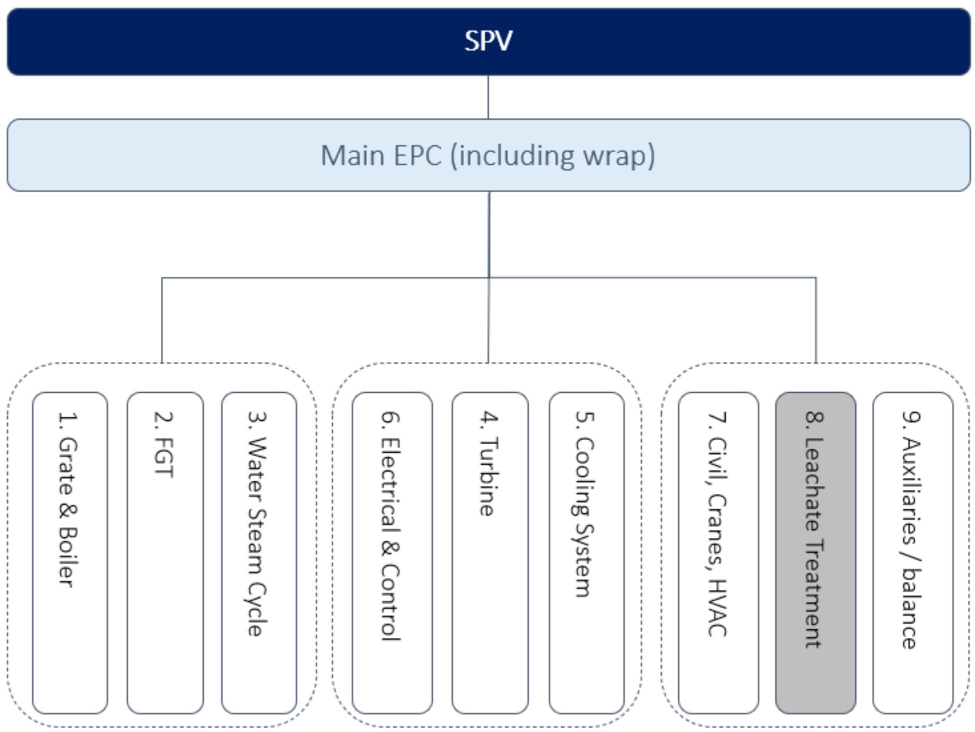

Figure 10 Division of Lots (based on 'best for project' principle) – Leachate Treatment is highlighted because during feasibility phase it will be decided if constructing such equipment is required for this Project.

The selected EPC provider will be strongly encouraged, through a contractual obligation, to use local resources as much as possible to comply with local labour requirements from the RFB. In the interest of proper execution of this new technology for the local EPC companies, we would like to focus this primarily on Civil works (as per Lot 7) as well as workforce available to support specialized suppliers and for support services/general services like warehousing/security/cleaning etc. The consortium performed due diligence on MACC[6] for a role as an EPC and or to take on the civil works for the project. It was found that the company is well positioned to perform parts of the civil works and even the total EPC.

Together with our consortium partner ITEC[7], we will source local contractors and operational personnel as provided in scheme 4.2.2. This scheme provides an overview of operators, maintenance, and other supporting staff necessary for a safe and efficient operations of the plant.

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[6] http://macc.ps/ar

[7] http://www.itec.ps/aboutUs.html

4.2.2 *Manpower during O&M / Concession period*

There are no specific requirements to operate the proposed High Efficiency WTE plant at Zahrat Al Finjan compared to operating a conventional WTE plant. A total of approximately 120 operational staff is the estimated manning level required to operate the plant 24/7/365.

An estimate of the personnel and their roles versus what is necessary to operate and maintain a plant is found in the table below:

Department	Field of control	Field of control	Field of control	Field of control	Total
Operations	Operators	Crane Drivers	Operations support		
	30	10	8		**48**
Logistics	Terrain Supervisor	Acceptation	Weighing bridge Operator	Residual processing	
	1	8	4	10	**23**
Quality	Process Technology	QA/QC	Document control	Lab	
	2	2	2	2	**8**
Safety	Safety operator	procedures	Environmental permits	Training	
	2	1	1	1	**5**
Maintenance	Cleaners	Mechanical	Electrical	Instruments	
	10	5	5	2	**22**
Finance & Office	Controller	Staff	Financial		
	1	4	2		**7**
IT & Process control	Office IT	Process control			
	1	2			**3**
Management	Operations	Finance	SHEQ	Plant Manager	
	1	1	1	1	**4**
Total					**120**

Table 1 Operational Staff estimation

Operations staffing

The staffing and sourcing of the best suitable personnel will be organized by consortium partner ITEC. Through ITEC, professional recruitment procedures will be applied and based on their experience we will select the most fitting personnel for the given the required skills, certification and knowledge for the jobs. The local presence of Koblenz and ITEC will ensure an optimal positioning of our consortium given their knowledge and access to the local labour market. The level of education of the local population is expected to be sufficient for most of the roles mentioned above and through our local consortium partners we have good contacts to all the professional communities surrounding Jenin.

For staffing of the management team of the new plant, the management committee of the SPV will be consulted to select the operational management candidates based on CV's and the project manager's recommendations. During the development of the project, the SPV management committee will also select the most suitable individuals from local professional services providers to staff the O&M phase based on skills and certification (if available). The selected personnel will receive training before the plant starts operating. This will be explained in the section on training and knowledge transfer below.

The general structure for the organization to manage the plant during the concession period is depicted in the figure below.

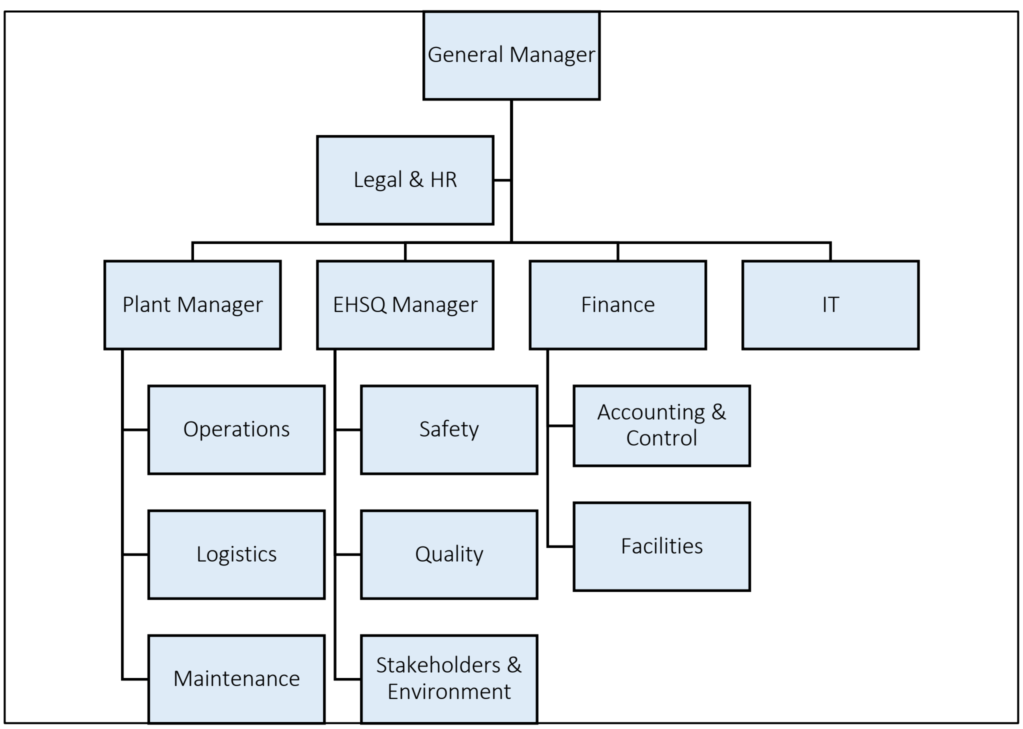

Figure 11 Organizational Chart during Concession period

Training and knowledge transfer

Consortium leader AWECT is currently developing a training centre in the Netherlands. Our so-called *Energy Academy* training programme is focused on training current and future personnel for operations of and in WTE and Biomass plants. The Energy Academy consists of a centre of expertise, a knowledge platform, and a learning and development approach based on job profiles and requirements from the industry combined with modern training content and methods, such as e-learning, simulators and other modern training tools at hand.

Via the Academy we will start a train-the-trainer program to ensure that new WTE plant workforces are properly prepared before operations of the new plant commence. Operational teams shall get additional insights via short training courses next to operating the plant. The training via the Academy will come in the form of a customized training plan to be set-up for the O&M Phase throughout the Concession Period for the specific plant in this Project. The training will be continuously updated to support the adequately trained and certified (if needed) personnel.

Transfer of knowledge will already take place during the Design and Construction phase and continue into the Start-up and Operations of the new WTE plant. It involves a transfer of knowledge from the international consortium partners to the Palestinian workforce that will be running the plant during the O&M phase.

4.3 Equipment procurement and utilization

The figure below sketches an overview of the core of the HE WTE plant with its key components such as: boiler & grate, steam turbine, e-generator, economizers, and flue-gas treatment. This scheme provides a general overview and should not be interpreted as final design for the proposed plant. Slight variations are possible due to manufacturers' specific design, or they are the result of calculations and modelling to be completed during Basic Engineering.

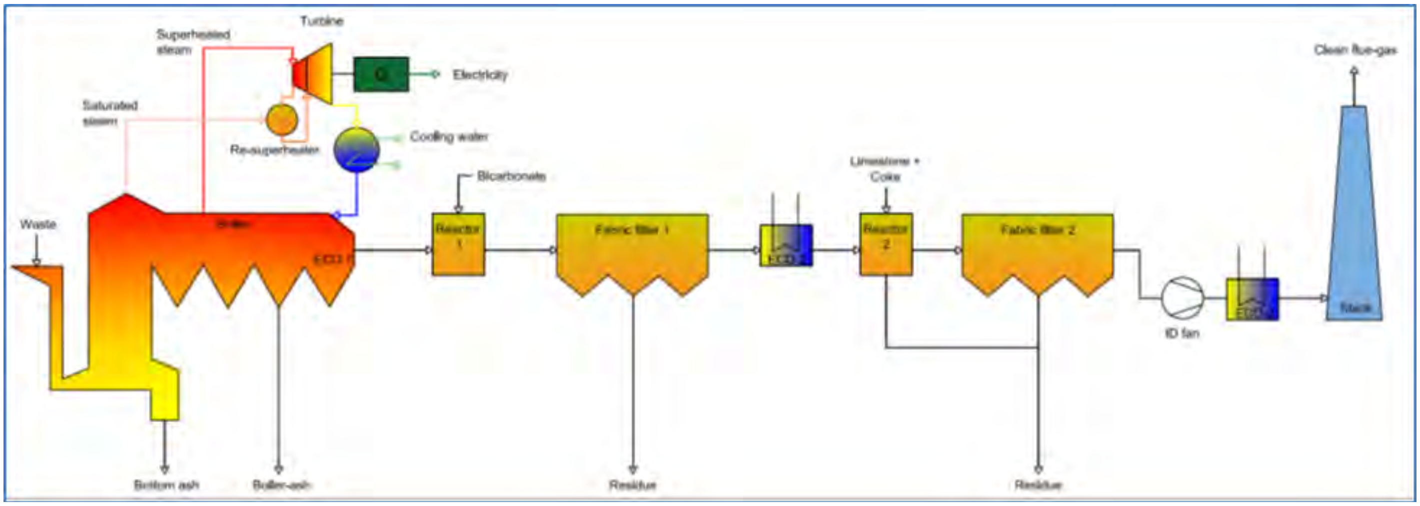

Figure 12 Plant scheme of High Efficiency WTE

Each contractor will be responsible for their lot or lots and the Main EPC will be responsible for their lots and overall integration (see Figure 10 in paragraph 4.2.1). As part of this responsibility, each contractor will need ensure timely and procurement of equipment following the exact specifications as set out during the Basic Engineering phase. A list of key components and major equipment, with further information is added in Appendix F.

Local Procurement

At the start of the Project, during the feasibility phase, a study will be conducted investigating the availability of (parts of) the required equipment procurement list from Palestinian local products and suppliers as per clause 17 of the Concession Agreement.

As mentioned prior, local services and products shall be used during the Concession Period if suitable and sufficiently available. Together with our consortium partner ITEC we will source local contractors and operational personnel. For EPC and civil works, we are in advanced discussions with strong local EPC companies.

4.4 Procurement and Contracting activities

The Procurement & Contracting plan will be created by the Contract Manager (and team) during the feasibility phase. The plan will contain an approach for the long-lead and critical items, which shall lead to official quotations in price and delivery times.

For the remaining equipment and services to the following steps shall be followed:

- Market screening local and international (minimum standards to qualify as supplier)
- Requirements per item or lot outlined (‘need to have’ and additional demands)

- Requests for quotation (RFQ) to be scheduled (detailed planning)
- Minimum of 3 bids to be achieved (unless decided otherwise by Management Committee)
- Selection and negotiations planned as per RFQ schedules

The above will follow a transparent tendering process based on Best Value Procurement philosophy, to select the most economically advantageous tenderers (MEAT) within given boundaries.

4.5 Support Infrastructure

The required local support infrastructure and generic services will be provided or sourced by consortium partners Koblenz (who have successfully managed the adjacent Landfill site since 2009) and ITEC for local services. Where possible these services can and will be shared to allow for economies of scale and best value.

Northern Consortium

5 Area Allocation Statement

5.1 Specific Requirements according to RFB

"The Bidder shall set out the area utilization plan for the Project Facilities."

Scoring Parameters

Criteria	Parameters	Paragraph	Weight
Area Allocation Statement	- Overall layout plan	5.2	10 / 100
	- Mandatory Facilities placement Support Facilities Placement Storage Facility	5.3	
	- Site Conditions	5.4	

5.2 Site location and overall layout

The Basic Engineering of the 1200tpd High Efficiency WTE *Zahrat Al Finjan* plant will include all required infrastructure equipment and facilities for the incineration process (in line with the key components as outlined in section 2.4), plus offices and workshops.

As can be seen in Figure 13 Overview of Zahrat Al Finjan Landfill area and Figure 14 Preliminary Impression and layout for WTE plant at Zahrat Al Finjan below, the location of the plant is in the projected area Northwest of the current landfill site.

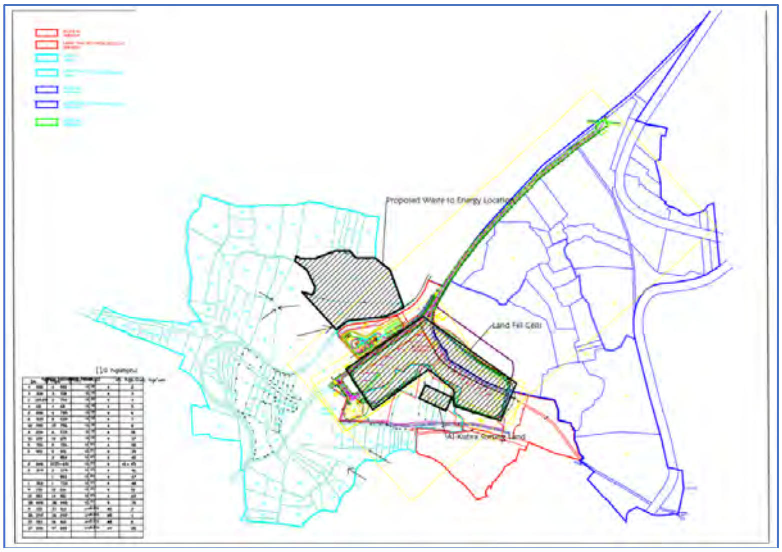

Figure 13 Overview of Zahrat Al Finjan Landfill area

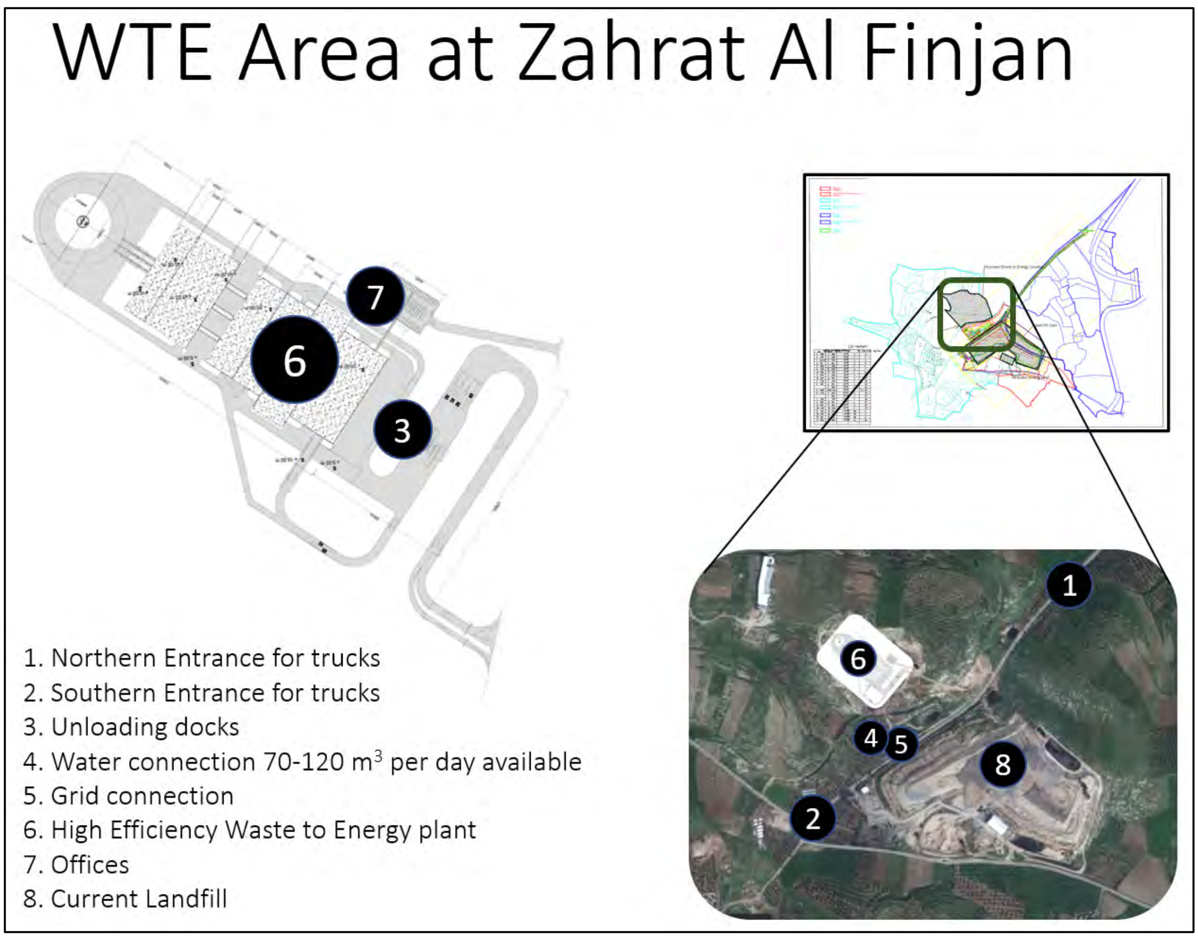

Figure 14 Preliminary Impression and layout for WTE plant at Zahrat Al Finjan

The Conceptual layout is typically planned in 3 parts:

- The middle area [6] is for the main incineration plant;
- The rear area (North of the main building) is for the other auxiliary facilities like storage, slag treatment comprehensive utilization plant and possible material recovery options, workshops and administrative building;
- The front area [7] is reserved for offices, public areas, educational centres, etc.

On the project site, we will separate garbage trucks, waste logistics [1], [2], [3] and offices [7] in smart split arrangement allowing for focus on respective aspects of health, safety and environment. The flow of the main processes is organized to avoid any possible interference, hold-up or create safety issues and it allows for easy access of the facility for operations, maintenance and safety purposes (i.e. repairs, firefighting and first-aid).

The main production plant [6] is designed in the middle of the plan; the main building is the key and core of the plant layout.

Plot size	Size
WTE technical lay out	1,5 ha
Workshops utilities public spaces and logistics	1,5 ha
Slag treatment and storage (to be agreed with the adjacent landfill)	2 - 4 ha
Total	**5 - 7 ha**

Available space at the landfill according to the RFB is 5.5ha. This available space will be sufficient to accommodate our proposed plant. Possibly the slag treatment and some storage areas can be located at or be combined with the current landfill operation.

5.3 Facilities Placement

Further to the arrangement of buildings and components on the site as per the above, the following principles are to be included in the plot plan to be developed during the design phases FEL-2 and FEL-3:

- For accident prevention, the refuse delivery and other plant traffic are separated.
- Major process technology components are arranged in one line, which provides a clear and simple overall plant structure.
- The separation between the boiler house and the flue gas treatment provides the additional access needed for maintenance purposes. Moreover, this allows natural lighting and aeration.
- Turbine and generator are arranged under the horizontal boiler pass, which saves space and enables short piping distances.
- In order to provide easy access to the plant in case of emergencies, all plant divisions are easily accessible from a surrounding ring road.
- The sufficiently large staging area until the weighing bridges avoids queuing of delivery trucks on the main road. The trucks will reach the elevated level of the tipping hall directly via the straight outdoor ramp to avoid difficult manoeuvring.
- Buildings are cladded and treated architecturally for a better image of the plant.

The longitudinal section shows the arrangement of the major process components, with delivery hall and bunker on the left, grate boiler and turbine in the middle, and double dry flue gas treatment to the right.

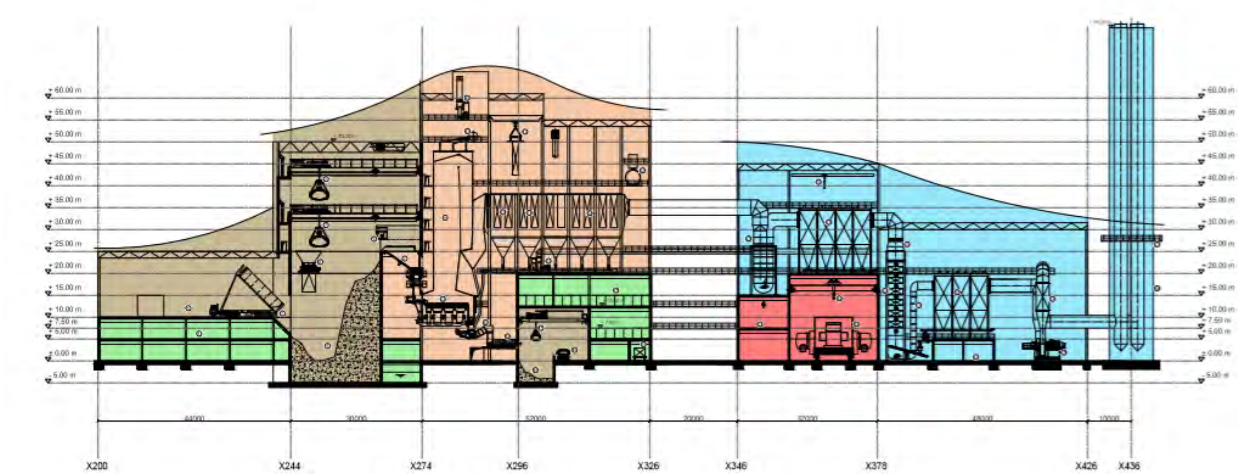

Figure 15 Longitudinal section of the proposed WTE with double dry FGT, see Appendix G.

Traffic arrangements

To cope with incoming traffic and avoid traffic queuing on the roads outside the facility, we intend to set up a ring road around the plant. Along this road, green belts are placed, forming a landscape Avenue.

Depending on the elevation of the main entrance to the site, we expect an elevated access will be created leading towards the tipping hall. This elevated access road will be constructed using a reinforced concrete structure. Figure 18 provides an example of this elevated road.

Figure 16 Waste Delivery (left) & Tipping area cross section (right)

5.4 Site Conditions

The site can be assumed to have no major obstacles and is free of underground obstacles, foundations, piping or cabling and war legacy. Pictures of the site below were made recently.

Our local knowledge of the location will be a big advantage to the project.

5.4.1 *Climate data*

Design Temperatures

Annual average	+22.0 °C
Maximum extreme	+38 °C
Minimum extreme	+0 °C
Highest monthly average	+33.0 °C
Lowest monthly average	+7.0 °C

Relative Humidity

Range (Annual Average)	53 to 63% (59%)

Wind

The wind speed varies between 3.3 m/s to 3.9 m/s.

5.4.2 *Site Access*

The site access for the waste delivery trucks is using the existing highway <60> which runs to the West of the plot. The entrance and exit into and from the plant for the personnel and the visitors are planned from the Southwest corner of the plot. The Northwest corner is allocated for the separate entrance and exit for trucks. This will be further assessed during the feasibility phase (FEL-2).

The site is adjacent to the Zahrat Al Finjan Landfill operations run by Koblenz, which enables us to potentially make use of:

- Entrance control
- Perimeter control and security
- Access to existing fire-water system
- Emergency response protocols in place

Northern Consortium

6 Operations and Maintenance Scheme

6.1 Specific Requirements according to RFB

"The Bidder shall set out the operations and maintenance scheme during the Active Operations Period. The maintenance (regular and emergency) schedules and mechanism should also be indicated over the Concession Period."

Scoring Parameters

Criteria	Parameters	Paragraph	Weight
Operations and Maintenance Scheme	- Overall O&M scheme	6.2	15 / 100
	- Regular maintenance plans	6.3	
	- Emergency maintenance procedure	6.4	
	- Risk management plan	6.5	
	- Hand back procedure	6.6	

6.2 Overall O&M scheme

The O&M scheme is part of the operational excellence scheme we propose to implement which provides a strict set of procedures following international standards as in ISO9001 and 14001.

6.2.1 *Start-up of Operations period*

During the commissioning / start-up period (chapter 7.2), a 'start-up team' will be established by the EPC contractor. The start-up team is responsible for a smooth transition from Construction to Operations. The start-up team (as a part of the EPC contractor's responsibilities) must perform its handover to a guarantee team (as a part of the O&M contractors responsibility). During design and construction the guarantee team from the O&M contractor will work together and learn how to operate the actual plant (after the training through the Energy Academy as explained in chapter 4.2.2) in cooperation with the start-up team in order to ensure a smooth handover.

The key responsibility of the O&M contractor is to deliver the performance based on the design specifications of the Northern Consortium during the design phase. The guarantee team will contribute to this goal and ensures all key parts of the plant remain compliant with agreed design parameters. The guarantee team will perform these checks and set up the (possible) claims for the suppliers of the equipment if they may not meet the desired specifications.

This process of handover from Construction to Operations phase, will be supervised by the Northern Consortium.

6.2.2 *Operational scheme*

The 'operational scheme' is defined as a set of regulations (e.g. local/international (labour) laws, agreements with labour union, EHSQ-conditions) and boundaries (e.g. emission limits, grid connection boundaries, performance requirements) that the operational schedule – provided in next chapter - will comply with. The scheme will:

- Ensure the performance of the HE WTE facility, in line with the Northern Consortium proposal and the details from the design phase.
    - Performance is defined in electrical output, emission standards compliance, use of excipients, safety targets, availability at the lowest costs (TCO)
- Guided by stringent SHEQ targets and standards ISO14001
- Comply with national legislation and with international labour laws and standards according to the International Labour Organisation (ILO)[8], including the Hours of Work (Industry) Convention[9]. At the same time, it will secure workers' rights in the workplace, such as against workplace aggression, bullying, discrimination, gender inequality, workforce diversity, workplace democracy and empowerment.
- Everything will have quality control and reporting following ISO9001/14001 standards.

The proposed operational schedule is provided in chapter 7.4.1.

All operational handlings will be captured in so called SOPs (Standard Operating procedures), which will be described in a step-by-step procedure and checklist specifying how to deal with standard situations in the plant. This will be part of an operational handbook which will be delivered at COD.

6.2.3 *Maintenance scheme*

The 'maintenance scheme' covers the maintenance design principles. It defines the various types and frequencies of maintenance applicable for each component (condition based, time-based, predictive, preventive, corrective, etc). This scheme is the basis for the overall maintenance schedule.

The scheme will:

- Ensure the performance of the HE WTE facility, based on the Northern Consortium proposal and its design assumptions.
- Comply with quality standards (ISO9001/14001). As a part of this, a maintenance model is required. This is provided in the picture below, including references to chapters within this document.

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[8] International Labour Organisation
[9] Hours of Work Convention (Industry)

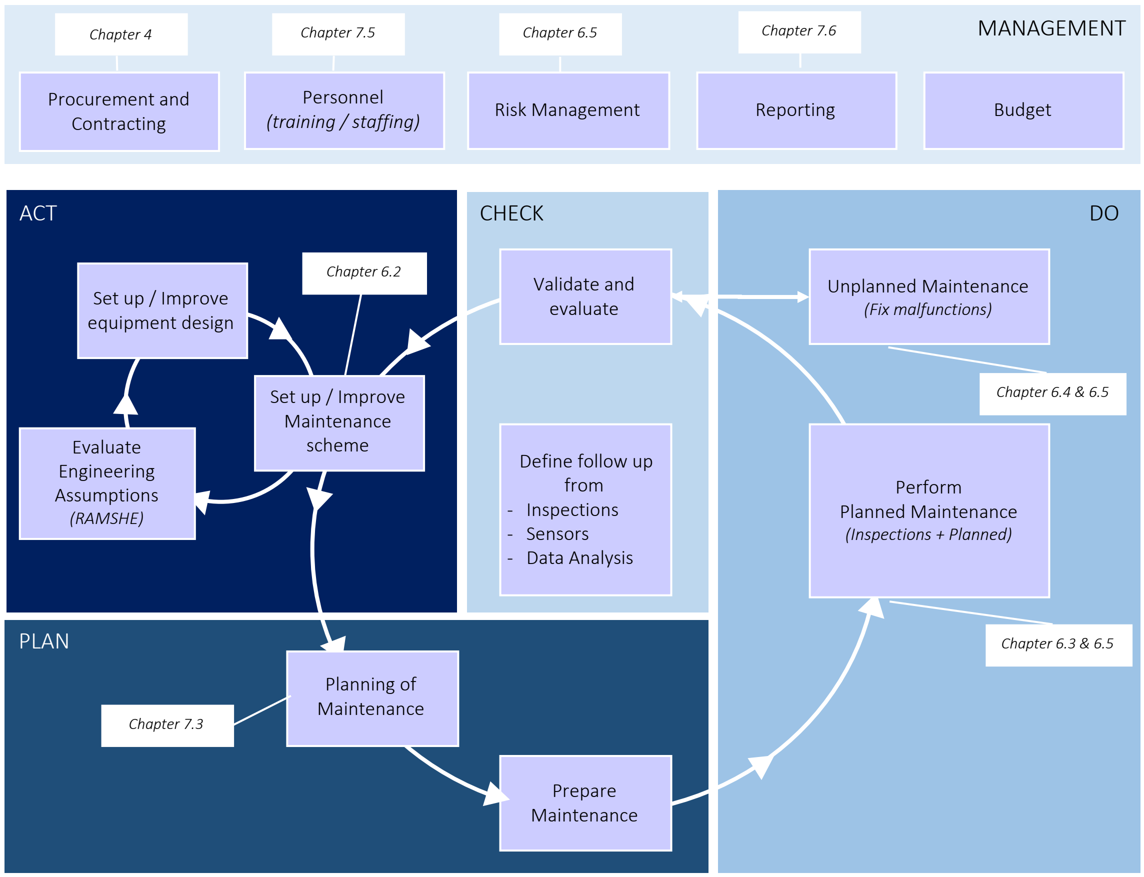


Figure 17 maintenance model

Explanation of this maintenance model is provided on the following pages.

The first maintenance scheme will be set up by maintenance engineers, based on performance requirements (RAMSHE[10]) from the basic and detailed engineering plans. Depending on the criticality of the equipment and known failure data, various techniques can be applied (e.g. FMECA, RCM[11]). Suppliers must provide input for the maintenance scheme based on the specific performance characteristics and maintenance requirements of their supplied equipment. To ensure continuous improvement on performance, a strict PDCA circle will be put in place:

[10] RAMSHE: **R**eliability, **A**vailability, **M**aintainability, **S**afety, **H**ealth, **E**nvironment. Design criteria

[11] FMECA: **F**ailure **M**ode **E**ffect & **C**riticality **A**nalysis; RCM; **R**eliability **C**entered **M**aintenance. Both methodologies to define a maintenance scheme

PLAN	Based on the maintenance scheme, an annual maintenance schedule is set up and the planned maintenance will be prepared in detail (§7.4)
DO	Planned and unplanned maintenance will be performed by specialized service engineers or companies, following fixed procedures (§6.3 and §6.4)
CHECK	Based on inputs from the work performed or data - obtained from inspections or sensors – standard follow-up procedures will be defined. Also, information of failure reports and maintenance data will be analysed.
ACT	Based on these evaluation results, improvements of the maintenance scheme will be applied. Also, these results will be important input for the 'guarantee team', described in paragraph 6.2.1.
MANAGEMENT	The maintenance processes (PDCA cycle in bottom part of picture) will provide input for the management processes (top of the picture) and vice versa, including reporting.

6.3 Regular Maintenance Plans (planned maintenance)

All measures necessary to achieve the overall plant availability of more than 90% will be detailed in the Definition Phase (basic design), EPC phase (detailed design and maintenance scheme). In these phases, the adequate and economically feasible redundancies will be defined as well.

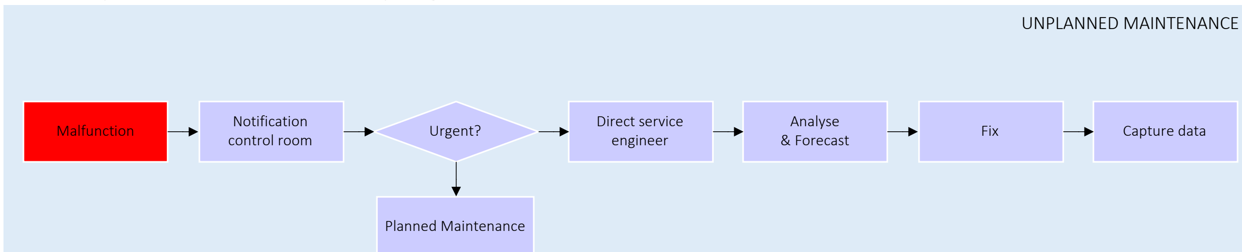
The HE WTE design is based on the experience gained in the reference plant in Amsterdam. Dedicated equipment – like sensors to monitor critical condition parameters - is also integrated in the design to achieve the extended service intervals, high availability and prolonged plant lifetime. The availability of 90% (ref. Appendix A – The Reference Plant) is therefore regarded as a likely minimum.

Based on our 100 years of operational experience with Waste to Energy plants we limit the interruptions caused by planned and unplanned maintenance, raising the bar to a plant availability of more than 92%. Similar to the Reference Plant in Amsterdam we expect to use a 2 years' maintenance interval of 17,400h. Because the plant requires a very high quality of components, maintenance (and this interval) usually forms part of the contractual agreements with the various equipment manufacturers. One shorter stop for inspection prior to the scheduled main revision is a common practice in WTE plant maintenance plans.

The maintenance scheme and schedule will be set up in close cooperation with the equipment suppliers, considering the lessons learned in Amsterdam. During the first year, after approximately 6 months of operation, an inspection stop must be scheduled. All critical items will need to be checked and measured to verify performance and compliance with the agreed design parameters. The guarantee team is responsible for the follow up with the suppliers and manufacturers.

6.4 Emergency maintenance procedure (unplanned maintenance)

This is an example of procedures, checklists, and SOP's for all commonly occurring events as part of the operational excellence program.



- Immediately after a failure has occurred it will be reported. Either manually by an operator or automatically detected by software and control system (depending on the type of failure).
- The notification will be assessed for urgency in the control room. If it is not an urgent failure – for example, no loss of function of the primary process or loss of redundancy of a critical process – the recovery will be planned via the regular maintenance process, described in the previous paragraph. O&M will define which type of malfunctions are defined as urgent based on the Failure & Risk Matrix as developed during the design phase. Typical urgent malfunctions are (not limited to):
    - Possible or imminent loss of functionality of the key processes
    - Possible or imminent loss of redundancy of the key processes
    - Possible or imminent environmental, health or safety issues
- In the event of an urgent failure of parts the service technician is directed to fix the fault as soon as possible. To this end, he will obtain all relevant technical information from the operators in the control room.
- Once on the spot, the service technician will start with a root cause analysis (RCA) and make an estimate of the duration of the recovery. It may be that only the function of the malfunctioning part is restored and that any residual work is planned through the regular maintenance process.
- After repair, the service technician must record and report all the data so that it can be used to improve the performance of the funtional unit.

6.5 Risk Management

An example of a risk management plan is provided in Appendix H. This risk management plan is based on the Northern Consortium O&M-reference (Reppie WTE). This plant is operated and maintained by specialized subcontractor Shandong Lineng Pvt. Ltd.

During engineering and construction, we will make use of a digital twin approach which mitigates risks between different suppliers at the interfaces. This digital twin secures as-built drawings delivered at start operations and provides a consistent database for operations.

Besides that, the consortium is developing a full scope simulator based on the reference plant in Amsterdam and modified for the project in Jenin. This simulator will check the performance and engineering assumptions in a simulated environment. The simulator will be used for training purposes as well, ensuring the O&M capabilities for the personnel of the plant.

6.6 Hand-back procedure

The ‘hand-back procedure’ is defined as the procedure to ensure how maintenance (planned or unplanned) is transferred to return to regular operating mode, in a controlled way.

Therefore, the maintenance scheme will be worked out in specific and detailed ‘job plans’. Besides a description how to carry out the work itself, these job plans cover steps towards operation, including (but not limited to):

- Communication with control room and operators
- Tools and materials needed
- Number of people and type of skills needed
- Measures to ensure personal health & safety
- Using lock out tag out system in combination with work permits
- By use of SOP’s (Standard Operating Procedures)

Hand-back procedures will be less or more extensive, depending on size and complexity.

Example of specific criteria for handing back a whole line (source: The Reference Plant)

Starting up a line from ‘cold’ status includes preheating by circulating hot feed water from the central system, and ignition of the refuse. An actual start-up from the cold normally will not be necessary as at least one line will be in operation and can deliver steam and hot water for preheating purposes. The first waste fed via the hopper on the grate will be ignited by a fuse or by start-up burners. Start-up burners are used to maintain the 2 sec. 850 rule, during start up and shutdown to avoid excessively Dioxin production and to stay within the emission limits.
The whole procedure is captured in a startup check list and prescription step by step. (SOP)

7 Time Schedule

7.1 Specific Requirements according to RFB

"The Bidder shall indicate an activity schedule over the Concession Period including the Construction Activities and O&M Activities."

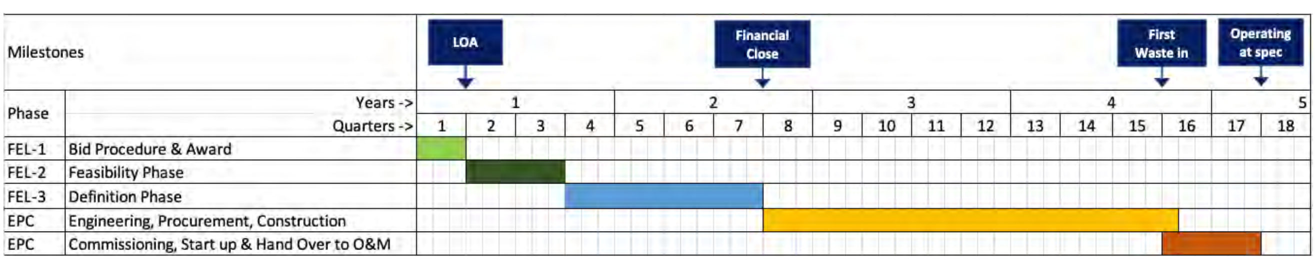
Scoring Parameters

Criteria	Parameters	Paragraph	Weight
Time Schedule	- Overall schedule	7.2	15 / 100
	- Construction activities sequencing	7.3	
	- O&M schedule	7.5	
	- Reporting and feedback timelines	7.6	

7.2 Overall schedule

The timeline for the realization of the WTE facility starts at the issuance of the LOA. The LOA is the trigger for the developer to start the Feasibility Phase (FEL-2), followed by FEL-3 (Definition Phase), including the Basic Engineering as well as the final arrangements for Financial Close. Some detailed engineering activities can start earlier, and long lead items need early commitment, but full release and the ordering of the remaining equipment, will require Financial Close.

The EPC phase will start after Financial close, by signing the contract with the Main EPC contractor. This phase includes detailed design, procurement of suppliers, construction, commissioning and hand-over to the O&M contractor. This period will take 30 months.



After 25 years O&M phase, the concession period will end. The Northern consortium proposes two options for this situation:

Option 1: Extend the contract, with comparable period and tariff (to be negotiated)
Option 2: Transfer the WTE Plant to authorities / MoLG. Procedure to be determined

A list of assumptions for the planning is included in the remainder of this chapter.

7.3 Construction schedule

7.3.1 *Approach and assumptions*

The nature, numbers and duration of the tasks involved, are site specific and depend on national and local regulations to a very high degree. Requirements by the investor and other stakeholders are relevant in addition and need elaboration in the Definition Phase (FEL-3).

The following list contains the main assumptions for the planning of the construction of the HE Waste-to-Energy facility:

- Financing assumptions have been included in chapter 2.
- During Feasibility (FEL-2) and Definition (FEL-3) phase, all agreements and permits (issued by local authorities) will be approved on time.
- Execution of the work adheres to local requirements regarding quality, health, environment and safety (to be assessed).
- Smooth transport and import procedures and timelines are assumed but are to be assessed.
- Long lead items such as the boilers, grates, turbine and generator, need to be procured before Financial Close. Assumption is that upfront purchase commitments are possible.
- Availability of workforce for civil construction and component erection (incl. requested material and machines) are available. This is to be confirmed.
- The planning assumes the timely review and approval by the client of detailed design in one (1) comment round.
    - when adjustments need to be made to approved design documents based on the clients review, consequences for the planning are not taken into account and need to be jointly agreed up front.
- All necessary data for the engineering are available at the start of the project, such as site surveys, climate conditions, etc.
- Investigation or delay for soil contamination, flora and fauna, archaeology, etc. has not been taken into account.
- No account has been taken of holidays and the likes.

There may be more issues similar to the ones listed above, which are relevant and may have to be taken into account putting together a realistic and comprehensive execution schedule for the HE WTE plant.

7.3.2 *Construction Activities Sequencing*

For setting up a construction schedule, best practise for WTE and expert judgement were used.

Starting points for the planning:

- where possible, work is done in parallel.
- the planning is based on the basic and detailed engineering.
- local delivery of steel structure based on prefabrication.
- the site is made ready for construction before start of civil work.
- average delivery times have been taken into account for key equipment and utilities.
- piping and electrical works are part of the lead times for equipment.

The construction schedule is provided in Appendix I (the start date is fictitious).

7.4 Operations and Maintenance Schedule

7.4.1 *Operations schedule*

During normal continuous operation, the plant is operated by a DCS system where all control loops are shown in automatic mode. This will be monitored by the process operators during their shifts. Apart from bunker crane operation during daytime, refuse delivery or during truck loading of bottom ash, personnel are required for surveillance and in case of disturbances.

Due to the nature of the fuel, waste, operator action is required at times. All relevant process information such as pressures, flows, position of actuators, speed of drives etc. are therefore monitored in the control room by specialized personnel, supported by real time information displayed on the screens of the DCS system.

Figure 18 Control Room of the Reference Plant

Any deviation of limits triggers an alarm and operators have full access to control loop set points as well as individual actuators and drives etc. In addition to the normal process visualization as the main man/machine interface, a video camera system provides process information regarding the refuse bunker, feed hoppers, bottom ash discharge and bunker and the fire in the combustion chamber. If required, operators act remotely from the control room.

As mentioned in chapter 4, there are no specific additional requirements in operating the high efficiency HE WTE compared to a conventional WTE plant. In total there are 8 people per shift in 3 shifts on a daily basis at a full reserve capacity to cover holidays and sick relief. A 5-team schedule works best both for the employees and for the employer. The working hours are effectively 33.6 hours a week.

Example:							
Team	mon	Tue	Wed	Thu	Fri	Sat	Sun
1	M	M	E	E	N		
2			M	M	E	N	N
3					M	E	E
4	N	N				M	M
5	E	E	N	N			

M = Morning; E = Evening; N = Night)

A part of the work can be outsourced and will not be carried out by the O&M teams of the facility itself. This work will therefore not impact the O&M schedule. This includes work which does not relate to the core of the operational knowledge, e.g. scheduled cleaning of the boiler. This work is to be done by specialized companies who have experience in overhaul of large energy plants and other process industries.

In the start-up period we foresee additional 10 persons (start-up team) who need to adjust and align the operations during the start-up period, keeping in mind that this period is typically characterized by start-up issues which needs troubleshooting. The aforementioned 120 persons are required for a smooth operation without major start-up problems.

7.4.2 *Maintenance schedule*

A maintenance schedule is provided in Appendix J. This maintenance schedule is based on the Northern Consortium O&M-reference (Reppie WTE). This plant is operated and maintained by specialized subcontractor Shandong Lineng Pvt Ltd.

7.4.3 *Training of personnel*

For certain positions in the operations and maintenance team, specific skills are needed. These people need to be trained by experienced trainers who have a long history in operating waste to energy plants. As explained earlier in paragraph 4.2.2, we will use our *Energy Academy* training program based on AWECT's knowledge of operating a HE WTE facility, to fulfil this need.

In general, basic knowledge of thermodynamics and chemical process technology are the most desired fields of expertise. The level of education for personnel differs per contribution to the process and the specific tasks.

Education level	Field of control
University ***6 persons***	Process technology with a background in chemistry, thermodynamics, management
University of applied science ***53 persons***	Operational management at the level: Process automation, electrical installation, process-operation, shift-leaders and maintenance manager, safety/environment
Professional education ***16 persons***	Operational personnel on the level of: Mechanics, electricians, it-specialist, operators, lab operator. Process-engineers chemical and thermal, office employees
No education ***42 persons***	Cleaners, residuals handling, logistics

Operating any waste to energy plant requires a variety of skills, part of these skills need to be developed inhouse. Training of the key personnel already starts when the Basic Engineering is started and HAZOP[12] / RAMSHE studies are conducted. This provides future personnel the opportunity to get in-depth knowledge of the installation and reasoning behind certain design choices and their effect on the operation.

Next to that, additional training of WTE specific theoretical background is to be given prior to the start of operations via the *Energy Academy (see paragraph 4.2.2)*. This includes knowledge regarding specific waste to energy equipment. With this theoretical background we can start the procedural training, which is specific to the designed plant using operational windows and operational prescription of the manufacturers as a basis. Part of the training program will be a team resource management (TRM) training, to create the right transparent and inquisitive culture for sharing information to operate and maintain the plant in the most efficient way.

Besides that, the right incentives should be established for proper operation of the plant: targets around availability, efficiency, safety and emissions are the most important to achieve. These goals are to be met within the budget set for these purposes.

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[12] HAZOP: Hazard and Operability Analysis is a structured and systematic technique for system examination and risk management. HAZOP is often used as a technique for identifying potential hazards in a system and identifying operability problems

7.5 Reporting and feedback timelines

Reporting of all operational events will be done automatically via a data historian, which will log all process parameters and events in the DCS system. Besides that, the operators will keep up a journal for all events which occurs during the shifts. All maintenance high priority working order will be logged and planned for upcoming maintenance moments.

During shift rotation a proper handover from this journal is provided to the succeeding team.

Every 24 hours, there is a daily operational coordination meeting involving operations, maintenance, and sales. All priorities for the day will be discussed and actions planned to ensure smooth, and safe operations of excellence which provide satisfactory result to all (intern/extern) stakeholders involved.

Weekly, monthly, quarterly reports will be produced to inform management and external supervising authorities/stakeholders. These reports will be following the principal of the PDCA cycle and international standards ISO9001/14001.

Especially the SHEQ reporting will be of interest to the supervisory authorities. Emission figures can be provided 24/7 and emission reports will be provided on a weekly base minimum. Together with the authorities a reasonable reporting scheme will be agreed. Following local regulations. Safety reporting will be done directly depending on the seriousness of the situation. This will follow the aforementioned risk matrix.

8 EHS Policy and Practice

8.1 Specific Requirements according to RFB

"The Bidder shall indicate the environment, health and safety policy and practices, which are proposed to be adopted during the Concession Period. The aspects relating to employee and worker safety, control mechanisms of pest, odor, fire, etc. needs to be elaborated."

Scoring Parameters

Criteria	Parameters	Paragraph	Weight
EHS Policy and Practise	- Environment management policy - Health practises - Safety related issues	8.2 8.3 8.4	10 / 100

8.2 EHS Management Policy

<u>General Statement</u>
For the Northern Consortium, Environment, Health and Safety (EHS) are key parameters during the development of the project. This is an important part of the DNA of all project partners. It will be our common goal to limit incidents to an absolute minimum and to prevent any environmental disturbance. The focus of the Northern Consortium safety policy will be at prevention of incidents by SOPs and checklists, supported by monitoring of leading and lagging indicators according to the best international standards.

During all development phases, all parties involved will be assessed to

- be certified according to international standards
- having in place an EHS training program that improves risk awareness and safety culture
- encourage responsibility for health and safety for both workers, management and selected companies or subcontractors
- having in place a monitoring system for safety.

As a consortium we will agree on the principles and targets, set in the general statement. Below is shown what EHS standards the Northern Consortium will apply, per phase.

Phase	Policy	Specialized Subcontractor
FEL-2 & FEL-3	ISO 9001:2015 ISO 14001:2015	Wandschneider & Gutjahr Ingenieurgesellschaft Companies for studies to be selected after LOA
EPC	ISO 9001:2015 ISO 14001:2015 ISO 45001:2018	China Western Power Co. Ltd. Koblenz ITEC - MOSECO Group
O&M	ISO 9001:2015 ISO 14001:2015 OHSAS 18001.2007	Shandong Lineng Electric Technology Co. Ltd.

- **ISO 9001** This International Standards Organization (ISO) standard specifies requirements for an effective environmental management system, addressing environmental policy, organization, planning, performance, and auditing and review. Compliance with the standard is verified with a third-party review, expert panel review, or self-declaration. The standard includes a process for accreditation of procedures, giving the organization formal recognition
- **ISO 14001** is an internationally agreed standard that sets out the requirements for an environmental management system. It helps organizations improve their environmental performance through more efficient use of resources and reduction of waste, gaining a competitive advantage and the trust of stakeholders.
- **OHSAS 18001** is one of the International Standard for Occupational Health and Safety Management Systems. It provides a framework for the effective management of OH&S including all aspects of risk management and legal compliance. It addresses occupational health and safety rather than any specific product safety matters. In the near future this will be part of a new ISO 45001 version.
- **ISO 45001** is an International Standard that specifies requirements for an occupational health and safety (OH&S) management system, with guidance for its use, to enable an organization to proactively improve its OH&S performance in preventing injury and ill-health.

Appendix K provides the certificates mentioned above.
Appendix L provides recent EHS efforts and results of China Western Power Co.

8.3 Safety related issues

Throughout the engineering and construction phase, we will use safety parameters which will directly be reported to the representatives of the owners, as stated in the Consortium Agreement. On the site it will be part of daily reporting. The following parameters will be recorded:

- Number of fatalities throughout the engineering and construction phase (Goal Zero)
- Number of injuries (maximum of xx)
- Number of medical cases (maximum of xx)
- Number of lost time injuries (maximum of xx)
- Number of consecutive days without casualties or injuries.

This will be used to calculate two key safety standards[13]:

1. **Total Recordable Incident Rate (TRIR)**
2. **Lost Time Injury & Fatality Rate (LTIFR)**

Albeit the ultimate goals for the above metrics should always be ZERO, general industry considers a good TRIR one that is below 3.0. The exact thresholds for the indicators ("xx") depend on the size of the workforce during the different phases and will be determined at the start of the project and communicated with all parties involved. These Key Performance Indicators will be important for the management of the project. Achieving of predefined targets will be enforced through a Bonus/Malus system. This will be also reflected in records and part of the reporting obligations to the project owner.

[13] According to OHSAS 18001 (to be replaced by ISO45001 at later stage)

9 Additional options

Based on the information provided by MoLG for this tender, e.g. the Feasibility Study Report from November 2018, and the local knowledge of our consortium partners, we firmly believe there are several opportunities (low-hanging fruits) for increased benefits at this specific location. These proposed add-ons should be investigated during the feasibility study phase in close cooperation with JSC and other local stakeholders.

<u>Eco-Park and increased waste recycling</u>
The JSC Governorate has seen a steady increase in the volume of waste disposed at the landfill. Based on projections, the waste volume is expected to grow further during the years of operations of the proposed WTE plant.

The Northern Consortium believes the WTE plant and operation of the landfill are complimentary (Northern Consortium partner Koblenz has performed operation of the landfill since 2009) and can be turned into a regional hub for waste management, a co-called Eco-Park. In an Eco-Park, various waste treatment providers such as the WTE plant for residual waste, waste segregators, plastic waste treatment, paper treatment, glass treatment, organic waste treatment through composting which can then be used as a liner for the landfill again can work in harmony to achieve maximum recovery of resources and as such become a starting point of the circular economy as referred to in the introduction.

Including these various additional waste treatment applications in the long-term concept around the waste to energy plant will help address the expected increase in volume of waste generated without the need to build additional WTE capacity or landfill waste again. Treating more waste through reuse and recycling is a preferred option in the waste treatment hierarchy compared to turning into energy via incineration. The Northern Consortium believes that existing infrastructure at the landfill combined with our expertise, knowledge and other technical solutions can be put to good use in the creation of such an Eco-Park and maximize recovery of resources.

The advanced bottom ash treatment system explained in paragraph 3.3 is part of this eco-park concept which will all work towards higher rates of waste diversion from the landfill.

<u>Further Methane and Greenhouse Gases (GHG) reduction</u>
The proposed plant presents the best-case regarding emissions, BUT we can do better. We propose to work together with the JSC and look at the business case to further reduce GHG emissions from adjacent sanitary landfill by installing a gas extraction system. The *Feasibility Study Report* states that this is an unavoidable solution anyway and we expect it to present synergies between the projects. Implementing this option would lead to a substantial decrease of odour nuisance, whilst maximizing the CO2 reduction and energy production at this location.

Northern Consortium

Wastewater treatment

Even though we do not envision or have plans for a leachate treatment facility in our project base case, also here we suggest to investigate adding this to the WTE facility as we are very familiar with this process and there are a lot of synergies with the WTE plant, the current landfill and providing this service for the region.

Knowledge transfer and research

Through the construction and operations of the proposed plant, a lot of knowledge transfer from the Netherlands to the Palestinian Territories will take place. This knowledge transfer and the indirect effects of this will positively enhance the local workforce and generate indirect spin-offs. If a more advanced waste management system is developed, research and further knowledge building through the cooperation of Dutch and local universities may be developed. Joint research programs and exchange programs could be developed which will further build local knowledge.

Definition of Acceptable Waste and Exceptions

***Acceptable* Waste**	***Exceptions***
Agreed quantity of Waste: 8,400 tons/week @ a Minimum average Waste Calorific Value: 2,300 kcal/kg (+/-10%), and a maximum average of 2,530 kcal/kg. Absolute minimum of 1,555 kcal/kJ and an absolute maximum of 5,980 kJ/kg.[1]	During major overhauls of the Plant and unplanned outages this can be discussed in consultation or the processing capacity of the Plant is insufficient for any reason
Household waste (e.g. waste released from households, such as food leftovers, paper, cans, plastics, textiles, etc. and that is collected door-to-door by a government-organized collection service in bags or (roll) containers of max. 240 liters)	None
Industrial waste (e.g. waste from offices, shops and (agriculture) companies that is comparable in nature and composition to household waste, such as food waste, paper, cans, plastics, textiles, etc. and which are offered in bags or (roll) containers made of max. 1700 liters)	None
Organic (e.g. Food and Agricultural waste)	Not acceptable when brought in large quantities like truck loads with, maximum quantity is 30% per Load - preferable to be recycled if possible
Plastic	all plastics with >1M% PVC
Hygiene Product (e.g. Diapers, pads, tissue, cotton, etc.)	Medical waste
Other combustible (e.g. rubber, textile, leather, styrofoam, etc.)	None
Hard paper (e.g. tetra cardboard, box, pack, etc.)	Big roles, with a diameter greater than 30 cm
Paper (e.g. office paper, magazine, newspaper, etc.)	Big roles, with a diameter greater than 30 cm

[1] Figures can slightly differentiate after basic engineering

Wood	Wood items that do not fit in 240 and 1,700 litre containers, or are larger in size than 122 x 167 x 92cm, or have. a diameter of more than 30 cm
Dense Plastic (e.g. PET/HDPE bottle, plastic container, etc.)	None
Glass	None

Non-Admissible Waste

Non-admissible Waste	***Exceptions***
In general, any Load containing: CL >1M%; and, S >0.1M%	None
Non-residential waste	Industrial waste as defined in Annex 1
Waste from extinguished fires, smouldering waste, or burning waste in general	None
Explosives	None
Asbestos	None
Radioactive waste	None
Vehicles tires	None
Sponge (e.g. matrasses)	If sizes are small (shredded)
Medical waste, medicines and cosmetics	Waste from healthcare institutions and the like that is not classified as specific hospital waste and does not contain any residues from humans (like blood, any parts of the body), bacteria's, any life forms causing diseases, carrying substances, sharp items (like needles, operation knifes)
Hazardous waste	None
Liquid waste	None
Dead animals (bodies or parts)	None
Sewage sludge , humidity,, or residues from process water cleaning like filter cakes	None
Garage workshops	Only general waste not being rags or oil containing materials or tires.
Flammable materials, oil and grease or pasty materials, asphalt and asphalt like, roof coverage etc.	Only when less than < 1M% of the total load
Slaughterhouse waste (chicken, cows, sheep)	None
Construction waste	Only general combustible waste when shredded to small pieces, not being PVC,

	inert waste or insulation material (pir/pur) only when <1M%
Fine Material (sand, dust and sweeping waste)	None
Non-combustible (rock, Stones)	none
Bulky waste	Only shredded combustible waste and when inert and insulations materials are less than <1M% of the total load
Any waste not permitted by the environmental permit or license	None

Annexure II – Minimum Administrative Requirements

Regarding this RFP, I the undersigned with authority on behalf of [name of Bidder Company]

Name: [..]
Position: [..]
Company: [..]

declare that the Proposal complies with the requirements, provided in the table below:

No	Requirement	Initials
1	Bidder is not in a state of bankruptcy, insolvency, or receivership	
2	Bidder is not subject to the suspension of its business activities	
3	Bidder is not subject to any pending criminal lawsuits	
4	Bidder is not listed on any debarment list published by multilateral financial institutions	
5	Bidder has no conflicts of interest in undertaking this assignment	
6	Bidder agrees to sign a Non-Disclosure Agreement with the SPV	

Although the requirements will apply to all subcontractors as well, the Consultant will be liable for its application.

This Statement has been made truthfully.

[signature]

[date]

Annexure III –Terms and Conditions

In general, Consultant must cooperate with information requests from the SPV’s lenders (i.e. access to the Consultant’s books, accounts and records, access to the Consultant’s premises).

FIDIC Client / Consultant Model Services Agreement, Fifth edition 2017 will be applicable.

Some clauses will be subject to negotiation with the selected Bidder.

- The SPV proposes to include additions and amendments to ‘Part A Particular Conditions’
- The SPV proposes to include additions and amendments to ‘Part B Additional or Amended Clauses’ of the FIDIC Client / Consultant Model Services Agreement’

Part A and Part B are provided on the next pages.

Particular Conditions

Part A. References from Clauses in the General Conditions

1.1 Definitions

1.1.4	Client's Representative	Lars Rijswijk
1.1.5	Commencement Date	1-1-2023 (conditional to PPA signing)
1.1.8	Consultant's Representative	[Name of Representative]
1.1.9	Country	Palestine
1.1.22	Project	[RFP name]
1.1.24	Time for Completion	[Time in days]

1.3 Notices and other Communications

1.3.1(c)	Communication	Email accepted

1.3.1(d) Address for communications

Client's address: Al Bolou, City Inn Building, Fifth Floor
Ramallah
Palestine

Email: (only when e-mail is accepted as a valid system for electronic communications)
l.rijswijk@harvestwaste.com

Consultant's address: [Address]

Email: (only when e-mail is accepted as a valid system for electronic communications)
[Email]

1.4 Law and Language

1.4.1	Law governing Agreement	Jordanian Law
1.4.2	Ruling language of Agreement	English
1.4.3	Language for communications	English

1.8 Confidentiality

1.8.3	Period for expiry of confidentiality	NDA signed with the client applies

1.9 Publication

1.9.1	Publication restrictions	NDA signed with the client applies

3.9	Construction Administration	N.A
7.4	Third Party Charges on Consultant	N.A.
8.2	Duration of Liability	
8.2.1	Period of Liability	Five (5) years
8.3	Limit of Liability	
8.3.1	Limit of Liability	[Amount]
9	Insurance	
9.1.1	Insurances to be taken out by Consultant	
	Professional Indemnity Insurance	[Amount]
	Public Liability Insurance	[Amount]
10	Disputes and Arbitration	
10.4.1	Arbitration rules	Rules of Arbitration of the International Chamber of Commerce
10.4.1	Language of arbitration	English

Part B Additional or Amended Clauses

The parties are to include in this section any variations, omissions and/or additions to the General Conditions.

- Annex 5 to be deleted
- Clause 1.5.2 to be deleted
- Clause 2.3.1 (a), (c), (d), (e) to be deleted
- Clause 2.4 to be deleted
- Clause 2.6.2 to be deleted
- Clause 2.6.3 to be deleted
- Clause 3.9 to be deleted
- Clause 4.4.1 (d) amends to *"any other event or circumstance, not attributable to Consultant, giving an entitlement to extension of the Time for Completion under the Agreement"*
- Clause 4.4.3 amends to *"Where any circumstance referred to in Sub-Clause 4.4.1 a) or b) causes the Consultant to incur Exceptional Costs, …"*
- Clause 6.1.2 (a) amends to "*When the Consultant has not received payment of an invoice or a part of an invoice, as the case may be, by the due date for payment of such invoice and the Client has not issued a valid Notice in accordance with Clause 7.5 [Disputed Invoices] stating the reasons for non-payment of the invoice or part thereof"*
- Clause 6.1.2 (c) to be deleted
- Clause 6.3.3 to be deleted
- Clause 6.3.4 amends to "The Consultant shall take reasonable measures to mitigate the effects of the suspension of the Services or part thereof. In case the Consultant incurs de- or remobilisation costs prior to the suspension or resumption, the Consultant and Client will work together to calculate appropriate compensation for the Consultant
- Clause 6.4.1 (a) period of notice 28d/14d to be reduced to 14d/7d
- Clause 6.4.1 (d) period of notice 56d to be reduced to 14d
- Clause 6.4.1 (e) suspension 168d to be reduced to 84d.
- Clause 6.4.2 (a) suspension 168d to be reduced to 84d.
- Clause 6.5.3 to be deleted
- Clause 7.3.2 (c) amend to *"impose taxes or differential rates of exchange for the transfer from abroad of Foreign Currency into the Country by the Consultant for Local Currency expenditure and subsequent re-transfer abroad of Foreign Currency or Local Currency up to the same amount, such as to inhibit the Consultant in the performance of the Services, then the Client agrees that such circumstances shall be deemed to justify the applicable of clause 4.6 [Exceptional Event], if alternative financial arrangements are not made to the satisfaction of the Consultant"*
- Clause 7.4 to be deleted
- Clause 10.2 to be deleted
- Clause 10.3 to be deleted
- Clause 10.5 to be deleted

Annexure IV – Project reporting template

REPORTING FORMAT TEMPLATE

Consultant	[TBD]	Consultant point of contact	Name / Email / Phone Number
Start / Expected Finish	xx	Scope of work Document (link)	xx

Key Objective(s):

- Objective 1, according to RFP
- Objective 2, according to RFP

Hold points / stage gates to be added as required

Monthly Update:

- Progress description, item 1
- Progress description, item 2
- Progress description, item 3
- Progress description, item 4
- Progress description, item 5

Deliverables / Milestones:

MS No.	Description	Due	Status
1	[Description]		
2	[Description]		
Decision point	[Description]		
3	[Description]		
4	[Description]		
5	[Description]		
Decision point	[Description]		
6	[Description]		
7	[Description]		

Risk log

Risk	Mitigation	Time Impact	Cost impact
Risk description	Status	Low	High
Risk 2	Status	High	High
Risk 3	Status		

Variations log

Variation	Status	Time Impact	Cost impact
Variation request #1	Status		
Variation request #2	Status		
Variation request #3	Status		

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1