35 MW Waste to Energy Plant
for
The Lahore Waste Management Company

Case Study

Presented by Hassan Jafar Zaidi

CEO, Power Planners International (Pvt.) Ltd. Pakistan

at

SAARC Workshop on Application of on-grid Biogas Technologies

16-17 May, 2016

Intercontinental Hotel Kabul, Afghanistan

Power Planners International

PPI

Background

- The Government of Punjab has initiated the development of a Waste-to-Energy power plant fueled by municipal solid waste (MSW)
- The plant will serve Lahore City, the capital of Punjab Province, Pakistan
- The first waste to energy grid-connected power plant in the city of Lahore, Pakistan
- The technology to be used is controlled combustion in a circulating fluidized bed (CFB) or on a moving grate (MG)
- The objective of this plant is to dispose of MSW in an environmentally friendly way by using it as a partially renewable (“green”) fuel in a state-of-the-art power plant that produces electricity for the Lahore grid.

Introduction

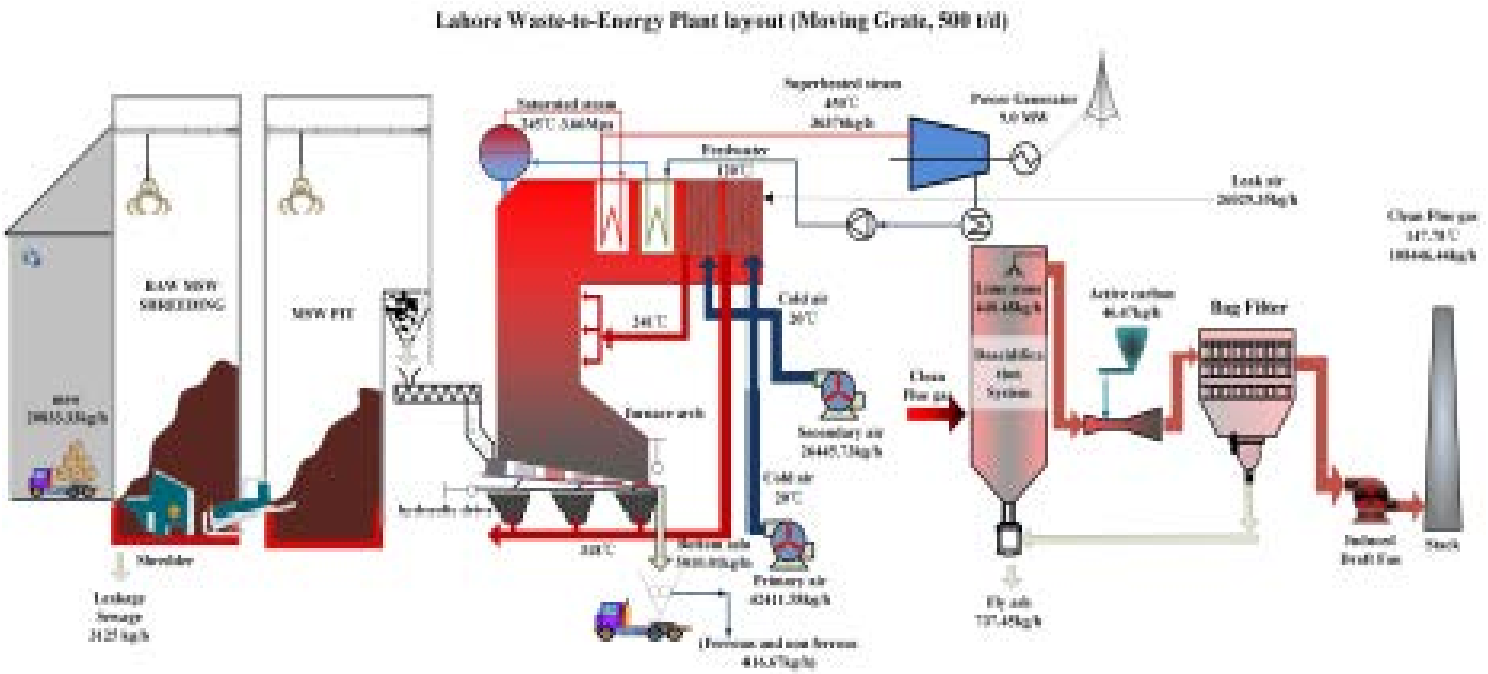
- The project will be managed by Lahore Waste Management Company (LWMC), a special purpose company established
  - to develop projects for collecting, processing and disposing of MSW
  - to produce electricity, heat, and recyclable materials
- The proposed facility will be located at a currently empty lot adjacent to the Lakhodair Landfill site that occupies an area of 125 acres.
- The facility will include
  - storage of MSW,
  - controlled combustion,
  - generation of superheated steam to power steam, electricity generating turbines,
  - cleaning of the process gas in a state-of-the-art Air Pollution Control (APC) system.

Salient Features

- The MSW shall be transported to the plant site by LWMC.
- The proposed project will include all equipment and facilities for processing the MSW and generating electricity
- The salient features of the project are provided below

Project total cost	**14 billion Pak Rupees ($140 million)**
Land area	**25 acres (101,000 square meters)**
MSW processing capacity	**2,000 tons per day (TPD); 600,000 tons/year**
Power generation capacity	**35 MW**
Water requirement	**36.3 TPD for steam generation**
Source of water	**Reprocessed and municipal supply**

Plant Layout



Power Planners International

PPI

Plant Performance

- The most efficient heat transfer between the hot flue gas and the water in the water tube boiler takes place via convection.
- High flue gas velocity gives high heat transfer, it increases the risk of high ash content in the flue gas.
- Some MSW types have high ash content, often with a high percentage of silica, a very abrasive material that is commonly used for sandblasting of steel constructions before surface treatment.

Plant Performance

- Super heaters (where the steam is given the last temperature boost before being sent to the steam turbine) are exposed to high flue gas velocities, and with abrasive fly ash, they are exposed to high erosion
- Highly efficient boilers can operate with flue gas temperatures at 180-200°C, with CO levels down to 150-20 ppm and corresponding oxygen level as low as 4%

Generator and Turbine Info

- According to the nominal capacity of the four combustion furnaces, the plant will be provided with two (2) steam lines of 75 t/h each and two steam turbines of total capacity of 36 MW. Technical parameters of each steam turbine set are as follows:

1) Condensing Steam Turbine	1
Unit Type	N18-3.43
Rated Rotation Speed	3,000 rpm
Rated Steam Pressure	3.43 MPa
Rated Temperature of Steam	(a) 390℃
Pressure of Air Discharging	(b) 0.01Pa (a)
2) Steam Turbine Generator	1 unit
Type	QF-18-2
Rated Power	18 MW
Rated Speed	3,000r/min
Frequency	50 Hz
Rated Voltage Power Factor	10.5 kV, 0.8
Excitation	Static Controllable Silicon

Regulatory

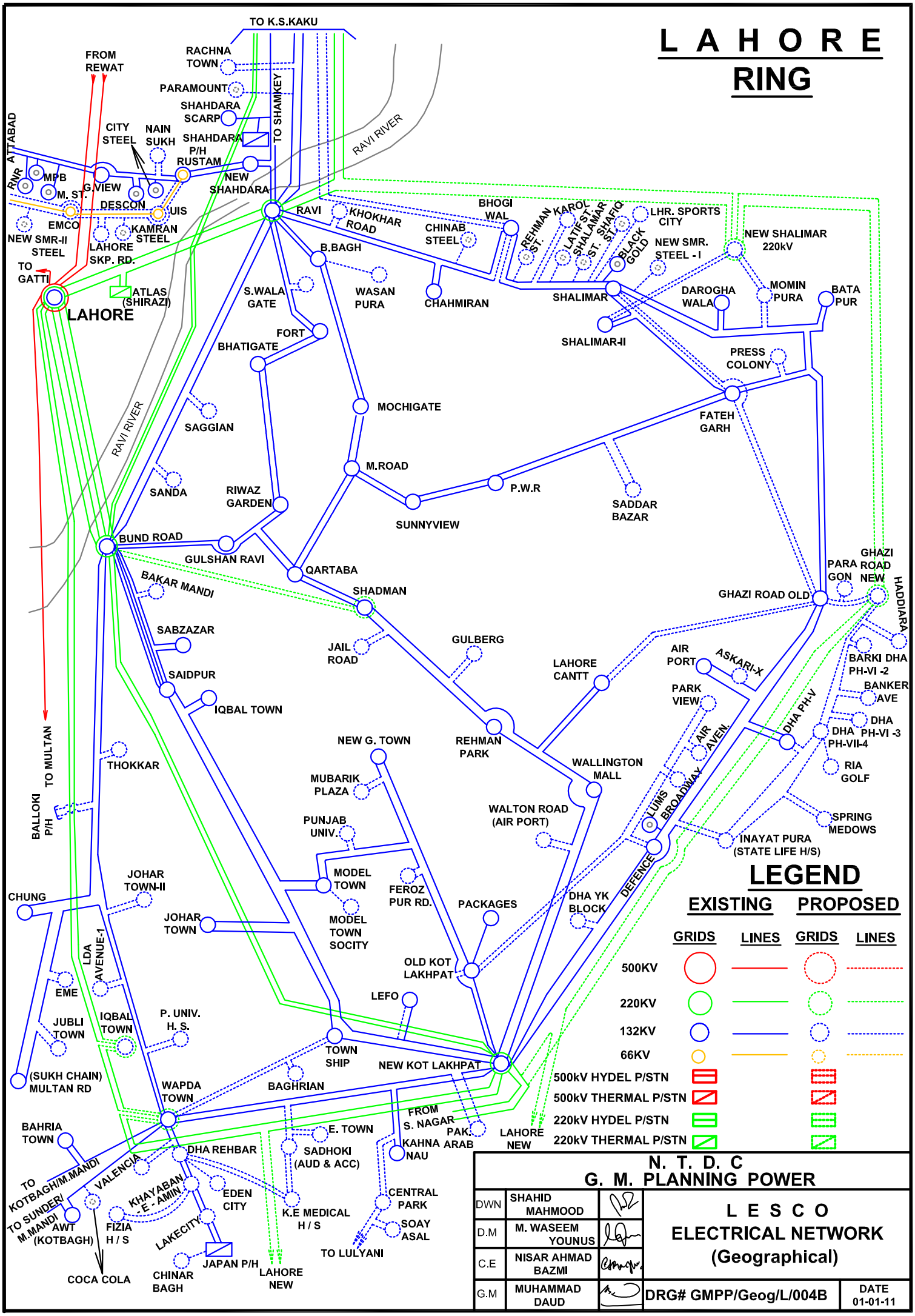
- The Policy for Development of Renewable Energy for Power Generation 2006 focused on solar energy, wind energy and small-scale hydropower projects of 50MW or less capacity.
- The Economic Coordination Committee of the Cabinet, in its meeting held on 6 March 2013, approved the Framework for Power Generation 2013 (the “Framework”) to address renewable energy from bagasse and biomass.

Regulatory

- The Framework is applicable to all bagasse/biomass based projects commissioned after January 2013
- NEPRA will determine the upfront tariff for bagasse/biomass based cogeneration projects. There shall be no requirement for a Feasibility or firm costs in case of upfront tariff.

Interconnection Study is Regulatory Requirement

- Under the Framework, Power Producers shall have the option to offer energy to respective DISCOs at 11kV or 132kV or to the CPPA at 132kV provided that the costs of interconnection and grid station upgrades for power evacuation shall be incurred by the respective DISCOs
- Power Producers will be required to submit Grid Interconnection Studies and Initial Environmental Examination Reports to relevant agencies / departments with copies of the reports and approvals to be provided to AEDB.


LAHORE RING
TO K.S.KAKU
FROM REWAT
RACHNA TOWN
PARAMOUNT
SHAHDARA SCARP
SHAHDARA P/H
TO SHAMKEY
RAVI RIVER
CITY STEEL
NAIN SUKH
RUSTAM
NEW SHAHDARA
ATTABAD
RNR
MPB
M. ST.
G.VIEW
DESCON
UIS
EMCO
KAMRAN STEEL
NEW SMR-II STEEL
LAHORE SKP. RD.
TO GATTI
ATLAS (SHIRAZI)
LAHORE
RAVI
KHOKHAR ROAD
CHINAB STEEL
BHOGI WAL
REHMAN ST.
KAROL
LATIF ST.
SHALAMAR ST.
SHAFIQ ST.
LHR. SPORTS CITY
BLACK GOLD
NEW SMR. STEEL - I
NEW SHALIMAR 220kV
B.BAGH
WASAN PURA
CHAHMIRAN
SHALIMAR
SHALIMAR-II
DAROGHA WALA
MOMIN PURA
BATA PUR
S.WALA GATE
FORT
BHATIGATE
PRESS COLONY
MOCHIGATE
SAGGIAN
FATEH GARH
RAVI RIVER
M.ROAD
SANDA
RIWAZ GARDEN
P.W.R
SADDAR BAZAR
SUNNYVIEW
BUND ROAD
GULSHAN RAVI
QARTABA
BAKAR MANDI
SHADMAN
GHAZI ROAD OLD
PARA GON
GHAZI ROAD NEW
HADDIARA
SABZAZAR
JAIL ROAD
GULBERG
AIR PORT
ASKARI-X
BARKI DHA PH-VI -2
BANKER AVE
SAIDPUR
IQBAL TOWN
LAHORE CANTT
PARK VIEW
AIR AVEN.
DHA PH-V
DHA PH-VI -3
DHA PH-VII-4
RIA GOLF
TO MULTAN
BALLOKI P/H
THOKKAR
NEW G. TOWN
REHMAN PARK
WALLINGTON MALL
MUBARIK PLAZA
WALTON ROAD (AIR PORT)
LUMS
BROADWAY
SPRING MEDOWS
PUNJAB UNIV.
INAYAT PURA (STATE LIFE H/S)
JOHAR TOWN-II
MODEL TOWN
FEROZ PUR RD.
PACKAGES
DHA YK BLOCK
DEFENCE
CHUNG
JOHAR TOWN
MODEL TOWN SOCITY
LDA AVENUE-1
OLD KOT LAKHPAT
EME
LEFO
JUBLI TOWN
IQBAL TOWN
P. UNIV. H. S.
TOWN SHIP
NEW KOT LAKHPAT
(SUKH CHAIN) MULTAN RD
WAPDA TOWN
BAGHRIAN
FROM S. NAGAR
PAK. ARAB
KAHNA NAU
LAHORE NEW
BAHRIA TOWN
E. TOWN
DHA REHBAR
SADHOKI (AUD & ACC)
TO KOTBAGH/M.MANDI
TO SUNDER/ M.MANDI
VALENCIA
KHAYABAN E - AMIN
EDEN CITY
CENTRAL PARK
AWT (KOTBAGH)
FIZIA H / S
LAKECITY
K.E MEDICAL H / S
SOAY ASAL
TO LULYANI
COCA COLA
CHINAR BAGH
JAPAN P/H
LEGEND
EXISTING
PROPOSED
GRIDS
LINES
GRIDS
LINES
500KV
220KV
132KV
66KV
500kV HYDEL P/STN
500kV THERMAL P/STN
220kV HYDEL P/STN
220kV THERMAL P/STN
N. T. D. C
G. M. PLANNING POWER
DWN
SHAHID MAHMOOD
D.M
M. WASEEM YOUNUS
C.E
NISAR AHMAD BAZMI
G.M
MUHAMMAD DAUD
L E S C O
ELECTRICAL NETWORK
(Geographical)
DRG# GMPP/Geog/L/004B
DATE
01-01-11

Fundamental Studies required for Interconnection Study

- PPI is conducting Interconnection Study constituting following main components
- Load Flow study
  - Steady State performance
    - Adequacy of loading limits of circuits affected due to interconnection i.e no overloading on any line/Transformer
    - Voltage profile to be within the Grid Code ± 5 % off-nominal
  - Contingency Analysis
    - No overloading on any line/Trafo under one line out condition (N-1 Criteria of Grid Code)
    - Voltage Profile to be within ± 10 % off-nominal

Fundamental Studies required for Interconnection Study

- Short Circuit Study
- 3-Phase and 1-Phase fault currents are calculated:
  - To determine the ratings of the equipment to be installed at the switching station of the power plant i.e. breakers, Isolators, CTs, PTs and other switchgear
  - To confirm if the fault levels on the substations in the vicinity of the new power plant are within the ratings of the equipment already installed there because fault current contributions from the new power plant would increase the fault levels on its neighbouring substations
  - To carry out protection coordination and relay settings of at the proposed power plant and also on the neighbouring substations if so required

Fundamental Studies required for Interconnection Study

- Transient Stability Study
- If the system stays stable and does not loose synchronism after any severe fault happens on the system such as 3-Ph or 1-Ph faults by monitoring
  - Rotor angles of generators of the entire system must stay in synchronism
  - Power swings on transmission lines must damp rapidly
  - Voltage on bus bars recover soonest to the acceptable level i.e. within 2-3 seconds
  - Frequency recover after any dips or over-frequency event

Interconnection Equipment

- Power generated from the power station will be stepped up to the evacuation voltage level of 132 kV through suitably rated generator transformers and will be evacuated through 132kV transmission lines.
- The system envisages a generator circuit breaker (GCB) in the generator output.
- The generator transformer, besides evacuating the generated power to the 132kV bus at the consumer end, will provide the start-up and shutdown power to the unit with the GCB in ‘open’ condition.

Interconnection Equipment

- There will not be any requirement of a separate station transformer connected to the 132kV grid.
- The power evacuation system will also be utilized to draw power from the grid for initial start-up. It has been assumed that grid failure, if at all, will only be momentary, hence it will be available for black start. Therefore, no other arrangement for black start, such as a DG set is envisaged.

Interconnection Equipment

- The 132kV air insulated switchyard (AIS) with double bus bar scheme.
- The 132kV switchyard will be provided with the following fully equipped bays.
  - 2-Generator transformer bays
  - 2-Bus P.T. Bays
  - 2-132 kV outgoing line feeder bays
  - 1-Bus Coupler
  - Each 18 MW unit will have one three phase, two winding transformer of 20/22 MVA rating (ONAN/ONAF
  - Generating voltage = 11 kV
  - GSU 11/132 kV, on load circuit tap changer

Financial Aspects

- If 75% of the US$140 million CAPEX is financed by debt at market rates and for the projected income assumptions (mainly the sale of electric power at US$140/MWh) there will be
  - a 10-year payback and
  - a projected internal rate of return of 9.8%.
  - The 25% equity piece is projected to return over 20% to outside investors.

Financial Aspects

- If no outside debt is used to finance the project,
  - the projected payback is 8.4 years and
  - the projected internal rate of return over 10%.
- The analysis also showed that even if the CAPEX were to rise by as much as an unexpected 50%, the project would still be economically viable

12 MW Mardan Solid Waste Management Power Project

Sponsored By

M/s GREENSURE E.S., Islamabad, Pakistan

Power Planners International

PPI

Site

Power Planners International

Background

- The special metropolitan area of Mardan has a population of 1.7 million.
- Its current solid waste treatment and disposal system has caused the city facing rapidly worsening waste problems.
- About 100 tonnes municipal solid waste out of a total 175 tonnes per day waste stream, primarily household, business and commercial waste (collectively termed municipal solid waste (MSW), is carried.
- The waste disposal is carried out without any sorting.

Introdcution

- It has the technology to convert organic fraction in MSW into combustible gases.
- The conversion shall be conducted in two ways:
  - biological conversion for converting easily degradable wastes into energy rich gas (methane, CH4)
  - gasification of other organics to become synthetic gases (syn-gas) at a limited amount of oxygen.
- Energy containing gases will eventually be used in the power generation process.

Objectives

- The objective of the project is to create a sustainable metropolitan municipal solid waste management system that supports GHG emission reduction.
- The targets of the project are as follows:
  - Reduction of MSW;
  - Increase of value added refuse;
  - Reduction of environmental and social problems at the disposal site;
  - Utilization of MSW to generate energy; and
  - Improvement of MSW management services

Benefits

The benefits of the proposed project are:

a) Reduction of environment pollution (in rivers and ground caused by waste disposal and air pollution from open burning of waste);

b) Overcome of social issues occurring from illegal waste disposal (open dumping);

c) Conversion of non reusable waste into combustible gases for electricity generation, for better economic benefits;

d) Utilization of municipal solid waste leading to reduction of the use of fossil fuel;

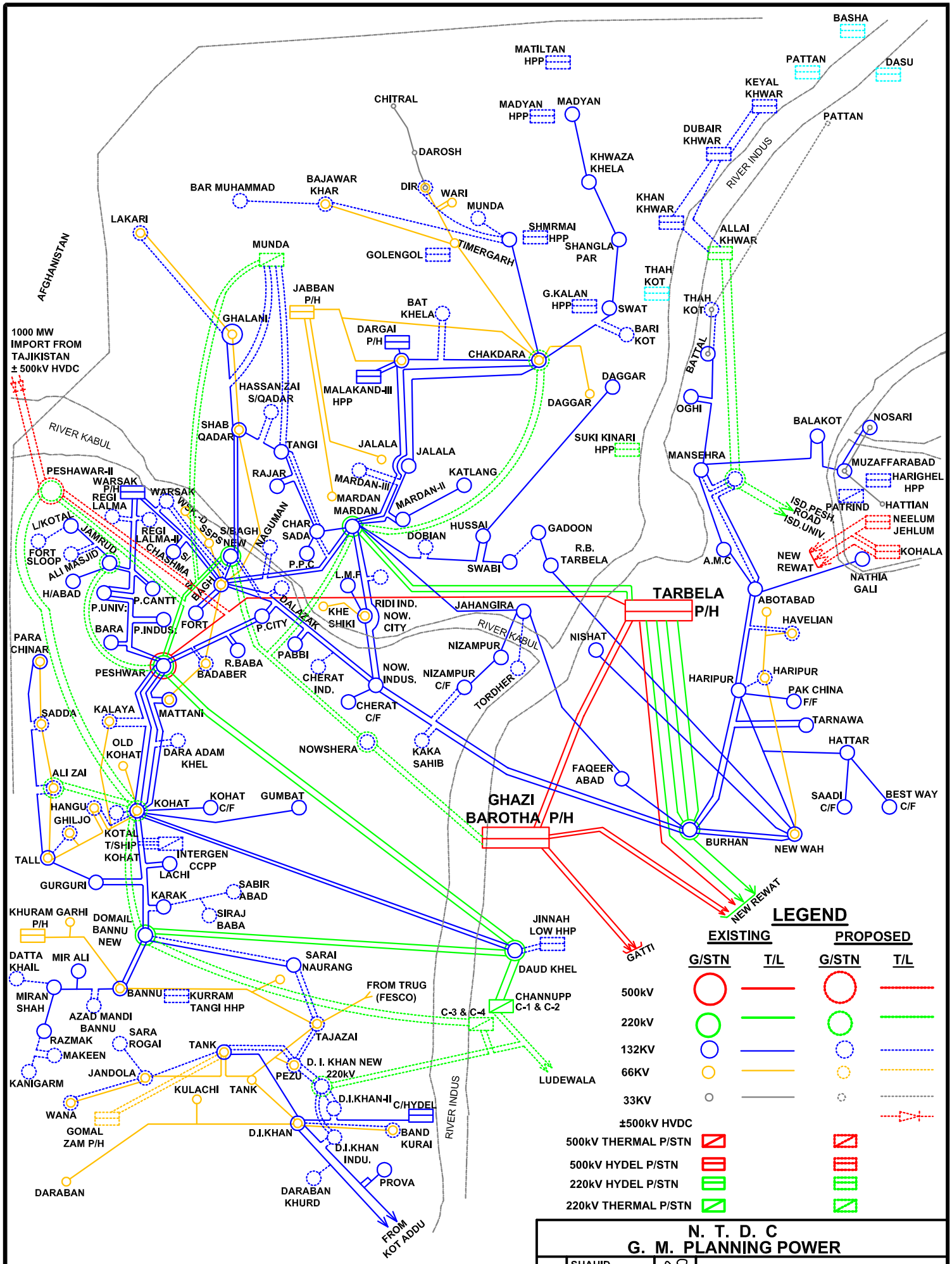
e) Reduction of GHG emissions;

Benefits

f) Cleaner environment for better public health (odor, seeping of contaminated or polluted water, potential spreading of disease);

g) Creation of job opportunities; and

h) Dissemination of a good municipal waste treatment technology to other locations in Pakistan



N. T. D. C G. M. PLANNING POWER			
DWN	SHAHID MAHMOOD		P E S C O ELECTRICAL NETWORK (Geographical)
D. M	M. WASEEM YOUNUS		
C. E	NISAR AHMAD BAZMI		
G. M	MUHAMMAD DAUD		DRG# GMPP/Geog/P/001 — DATE 01-01-11

Financial Analysis

- **Financing Plan**
- Local Foreign Total %
- **FUND REQUIRED** Proposed Project Capital Expenditure 87.08%
- Operating Expenditure 5.4%
- Financial charges during development 7.52% TOTAL PROJECT REQUIREMENT 100.00% **SOURCES OF FUNDS** Proposed Investment 75.00%, Other loan 00.00%, Equity or capital contributions - Government 5.00% Other sources 20.00% Subsidies for operation - - - 0.00% Internal cash generation - - - 0.00% TOTAL SOURCES 100.00%

Plant Layout

Power Planners International

Thank You
for Your Attention