SYNERGY ENERGETICS
Technological Research Investment Corp

STRICTLY CONFIDENTIAL

TENDER DOCUMENTS[1]

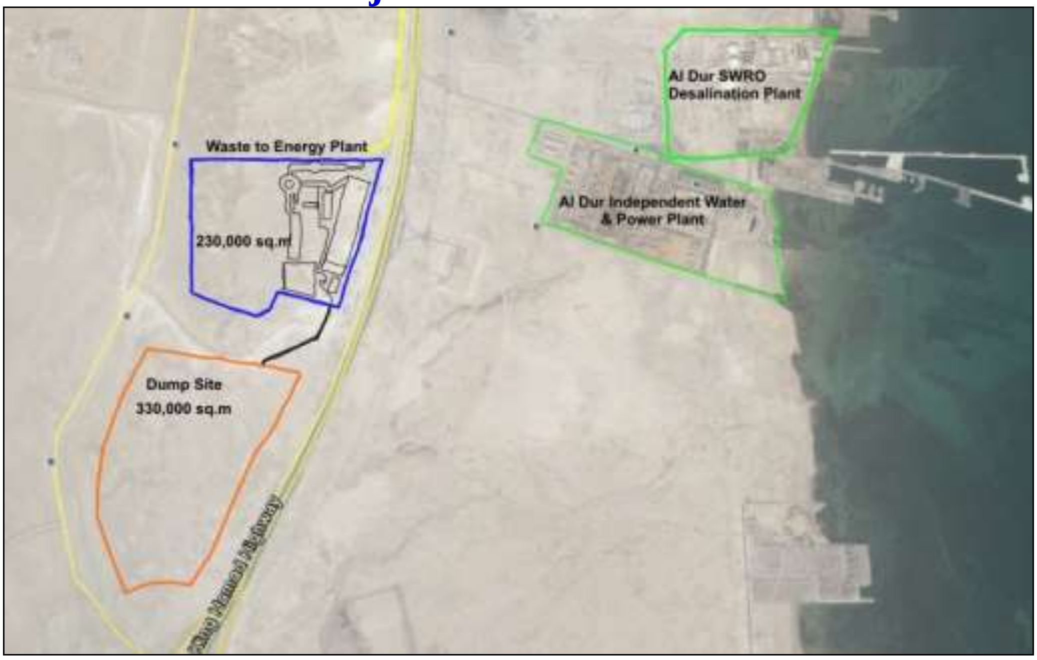
of

the development and establishment of a TCG-UC EL1500TH-TPY Energy Production System based on „Thermo-Chemical Gasification Technology”, the most environmentally-friendly energy generation process to utilize organic, municipal solid waste, and any carbonaceous materials or their mix in any proportion as feedstock with near-zero emissions, under the name of:

Tender ID.: RFP20141024786352

„TCG-UC BAHRAIN Project”

Project ID: 973/01/2014



Developed:

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Rev. No.: 18/11/2014

Denver/Zürich/Budapest, February 18, 2015.

[1] The final business and technology offer will be based on local conditions and specific data and requirements, consequently this document/offer can be modified before submitting the final offer without any notice.

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THIS DOCUMENT WAS PREPARED FOR THE

„PROVISION OF AN INTEGRATED WASTE MANAGEMENT SYSTEM"

TENDER, ISSUED BY

KINGDOM OF BAHRAIN, MINISTRY OF MUNICIPALITIES & URBAN PLANNING

TENDER NO.: **NO.MUN/20/2014**

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The applied abbreviations

Abbrev	Descrition
AUXS	Auxiliary Equipments
AUXS 1	Auxiliary Equipments Part 1
AUXS 2	Auxiliary Equipments Part 1
BOT	Design Build Operate and Transfer
BPEO	Best Practicable Environmental Option
FT	Fischer-Tropsh
FUPDC	First United Project Development LLC
GCPEW	General Commission for the Protection of Environment and Wildlife
GTE	Gas To Energy
ITH	International Trading House S.P.C.
MJ/d	Mega-Joule per day
MMA	Ministry of Municipalities and Agriculture
MSW	Municipal Solid Waste
$MW_e h/h$	Megawatt Electricity Hour per Hour
$MW_{th} h/h$	Megawatt Thermal Energy Hour per Hour
NAP	Not Available at Present
NEG	National Electricity Grid
NZE	Near Zero Emission
SEC	Security
SNG	Synthetic Natural Gas
sq.m	Square meter
sTPD	Short Ton Per Day
sTPY	Short Ton Per Year
TCG	Thermo-Chemical Gasification
TCG PP	Thermo-Chemical Gasification Power Plant
Tender documentation	PROVISION OF AN INTEGRATED WASTE MANAGEMENT SYSTEM **Invitation to Tender** (**No. MUN/20/2014**)
TPD	Ton Per Day
TPY	Ton Per Year
W2E	Waste To Energy
7/7 and 24/24	Seved days a week and Twenty-four hours a day

INTRODUCTION

The price of energy increases continuously, which results in a strong interest in the utilization of alternative feedstock materials such as municipal solid waste (MSW). This trend has been further strengthened by national regulations enacting increased levels of environmental constraint to the disposal of MSW, and strongly encouraging the utilization as sustainable feed material for energy generation of waste materials, especially those with high energy contents. The international pressure on the reduction of CO_2 emissions (which are widely acknowledged to be the chief contributor to the greenhouse effect) during energy generation places tremendous pressure upon companies involved in energy generation.

These were the two driving forces behind the new technologies that encouraged the scientist and engineers to develop a technology that will meet these new important economic and political criteria. The thermo-chemical gasification in an oxygen deprived atmosphere, which is the basis of the TCG-UC plant, meets or exceeds the previously mentioned strict criteria and the performance among the competing processes and plants presently on the market. This technology is protected by international patents.

The TCG-UC plants are constructed in a modular form, and are capable of utilizing almost any carbonations materials (or any mixture in any combination thereof) as feed stock at capacities ranging from 100 up to several thousand tons per day feed capacity. The plant was rigorously tested with different types of feedstock materials on large scale at commercial capacities.

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I. CRITERIAS, REQUIREMENTS AND BASIC DATA

Issuer : **Kingdom of Bahrain, Ministry of Municipalities & Urban Planning**

Title: PROVISION OF AN INTEGRATED WASTE MANAGEMENT SYSTEM

Tender No.: **NO.MUN/20/2014**

Date of Issuance: February, 2015.

A. Summary of Tender

The Kingdom of Bahrain generates over 1,500,000 tons of waste per year which is presently disposed of at the Askar Municipal Landfill Site located in the quarry area in the south of the country.

It is estimated that there are 23 million cubic metres of landfill space left, and the present infill rate of 1.7 cubic metres of space for each tonne of waste, and assuming an increase in growth of 5%, the Askar Landfill site will have been exhausted within 10 years.

The Kingdom of Bahrain, comprising of 36 islands with a total area of about 750 sq. km. is inhabited by a population of over 1,234,000 with a population density of around 829 person/sq. km. The current population growth rate is around 3% with more than 80% of the population living in urban areas.

The land resources of Bahrain are very limited and needs to be strictly protected against any form of pollution, which might affect the finite environmental resources of the country. Bahrain's environmental resources are considered to be very fragile due to its limited land availability.

The rapid industrialisation, population growth and increase in consumerism are causing significant increase in waste quantities which needs to be appropriately managed.
Municipal waste treatment has now become a national concern mainly due to the enormous quantities and types of waste generated, limited municipal capabilities, nonavailability of land resources, occurrence of serious marine pollution and human health implications.

The Municipality Affairs (MA) has been operating landfill as the main form of disposal for many years mainly due to high cost of other alternatives, and the availability of unused quarry areas at remote locations.

However, the rapid utilisation of land has now made it imperative to look now for a sustainable and integrated waste management, treatment and recycling system to reduce the amounts of waste going to landfill to less than 10% in a manner which is considered cost effective and environmentally friendly method of waste disposal.

The Municipality Affairs has undertaken a detailed review and assessment of potential waste technologies and developed a concept for the proposed Integrated Waste Management System (IWMS) for future management of waste.

B. The criterias

The study carried out by the Ministry of Municipalities and Agriculture in conjunction with SLR a leading Environmental and Waste Management Consultant from the UK, concluded that an Integrated Waste Management System is the preferred solution for the Kingdom of Bahrain, with the main criteria being

- Reduction of waste to landfill by at least 90% by volume
- Recycling or Re-use of materials of at least 65% by weight of the incoming waste
- Minimum use of water in the process
- Minimum adverse affect on the environment regarding
  - Minimal Global warming effect
  - Minimize Ozone Depletion
  - Reduction in use of Fossil Fuel
- Economic cost
- Employment opportunities for Bahraini nationals

The principle to be adopted is to Treat, Recycle or Re-Use the maximum amounts of waste prior to thermal treatment of the remaining elements of the waste stream which cannot be treated further.

The report compiled by the Ministry of Municipalities and Agriculture and SLR Consultants in their report entitled "Preparing an Integrated Waste Management Strategy for the Kingdom of Bahrain" in August 2005, concluded that of all the options available for waste treatment, the ones which provide the Best Practicable Environmental Option (BPEO) were:

1. Initial Reception Area for pre-sorting/separation
2. Separate re-cycling of the Construction Waste
3. composting of the source-separated green waste to energy to plant.
4. Thermal treatment of the remaining waste and/or mcmte
5. Landfill of the final residues which should account for no more than 10% by volume of the incoming waste stream

C. Description of the project requirements

The Ministry of Municipal Affairs and Agriculture in the Kingdom of Bahrain proposes to issue a Request for Quotation for the construction and operation on a Design Build Operate and Transfer ownership basis, (BOT) an Integrated Waste Management System for all the waste, excluding hazardous, toxic and medical waste arising in the Kingdom.

C.1. The key elements to the Project are:

1. The plant should comprise initial reception area for pre-sorting/recycling, process for the treatment of domestic waste, Recycling of Construction Waste, composting of green and garden waste, thermal treatment plant for the elements no longer able to be re-used or recycled, and a sanitary solid waste landfill.
2. The Integrated system should result in a high diversion of waste from the landfill
3. The Contract period shall be 25 years from the date of commissioning
4. The plant should be designed to accept un-sorted waste as the waste collection system operated by the Municipality does not allow for separation at source and therefore the recyclable materials are mixed with the putrescible, organic and other materials
5. The selected contractor is required to lease or rent the proposed premises, site or land for establishing the waste treatment facilities, preferably in one of the Industrial Areas operated by the Ministry of Commerce and Industry. The site is to be strategically located in the country enabling efficient movement, transportation, disposal and treatment of waste without interference, obstructions and impacts and should pose no threat to the environmental resources and public health. The site needs to be accessible in all weather conditions, have sufficient lighting and should have a capacity for expansion and extension.
6. The contractor is required to assess and provide all project permissions required for the project, including planning, building, way-leaves, etc for the services and infrastructures. The Employer will assist in obtaining all permissions necessary for the selected site but the onus for completion will be with the Contractor.
7. All components of the facility i.e. the reception, separation, domestic waste treatment, green waste composting, construction waste recycling, scrap cars treatment and thermal treatment, should be contained within the same boundary
8. The existing municipal waste collection, transportation and handling system and operations should not be hindered. The proposed system should integrate the existing system.
9. The risk for wastes to mix with the water/marine environment should be eliminated. The facility should not generate any obnoxious and hazardous odours.
10. The location and operation of the facilities should not impact adversely on the local community and resources.
11. The Contractor must provide an Emergency Procedures and Contingency Plan for the proposed waste treatment system.
12. Comprehensive Quality Control and Health and Safety Plan must be incorporated

into the tender submission.

13. The location of the site will be south of GPIC Company as shown in Appendix A.
14. The selected bidder shall consider in his business plan the reclamation of the land.

The main objective of this turnkey project is to Design, Build and Operate (BOT) an Integrated Waste Treatment Facility and Landfill which will treat the entire waste stream in the Kingdom of Bahrain to attain the prime objectives listed below using the Best Available Technology not entailing excessive cost, and to provide a cost per tonne for such treatment.

The contractor shall carry out the final design based on the frame conditions described in the tender document. He shall obtain the Municipalities Affairs approval of design and subsequently obtain permits and permissions from authorities.

The prime objectives of the solid waste facilities shall be

1. to reduce the amount of waste going to landfill by at least 90%

2. to produce recycled/treated/re-used products of very high quality from the incoming raw waste to maximum the marketing potential and thereby reduce the risk of processed materials ending up in the landfill.

***** Note (The processing of mixed solid waste to produce a low quality Compost for which there is no guaranteed sale will not be considered favourably)***

3. To protect the health of people and enviroment.

C.2.The plant will have to meet the following criteria:

- Handle, treat and dispose of commercial and household waste using safe, efficient and environmentally friendly methods;
- facilitate the extension of the plants and the addition of new facilities;
- provide flexible operation to handle, treat and dispose of various wastes in quality and quantity and operate with maximum reliability and minimal downtime due to equipment and operation failure;
- comply with Kingdom of Bahrain standards and environmental regulations for all emissions (noise, odors, dust, solid matter, liquids, gases) emanating from any part al all of the waste treatment facilities;
- follow the BATNEEC principle (best available technology not entailing excessive costs);

- use commercially technically proven systems and procedures and ensure optimum utilization of energy, manpower and processes;
- incorporate high technology and advanced systems and set new standards for facilities of this kind in the Arabian Gulf region;
- comply with all national technical standards mentioned in the contract;
- provide a cost effective, economical basis concerning investment and running costs with minimal manpower in attendance;
- Utilize minimum amounts of water in the process. Water consumption will be a vital element in the choice of system and the tenderer must clearly indicate in his submission not only the amounts used by also from where this water will be derived;

C.3. The declared intention of the issuer

The terms and condition concerning the establishing and operation of the project/plant are specified in both the Tender Documentation and in the contract between the issuer and the winner of the tender or the project company. The required daily feed/input material of cca. 3.086 tons of MSW will be provided by the Government of Bahrain, and origin from the cities and the smaller communities and villages of the country. Large quantity of old waste sites coupled with the significant quantity of new daily waste production assures sustainable input material supply, but this „old waste" is not element of this Integrated Waste Mangement project. The old MSW is not the subject of the this document or the agreement.

It has become very clear to many municipalities, cities and regions that to resolve and remedy the acute site, environmental and continuously increasing costs of waste handling and disposal can be accomplished by almost total utilization of the waste material by the introduction of new technologies like TCG technology. Failing such, governmental subsidies or waste management fees will have to be increased.

(Ref. Tender documentation section 1. Page 4)
"The study carried out by the Ministry of Municipalities and Agriculture in conjunction with SLR a leading Environmental and Waste Management Consultant from the UK, concluded that an Integrated Waste Management System is the preferred solution for the Kingdom of Bahrain, with the main criteria being

- Reduction of waste to landfill by at least 90% by volume
- Recycling or Re-use of materials of at least 65% by weight of the incoming waste
- Minimum use of water in the process
- Minimum adverse affect on the environment regarding
    a. Minimal Global warming effect
    b. Minimize Ozone Depletion
    c. Reduction in use of Fossil Fuel

- Economic cost
- Employment opportunities for Bahraini nationals

The principle to be adopted is to Treat, Recycle or Re-Use the maximum amounts of waste prior to thermal treatment of the remaining elements of the waste stream which cannot be treated further.

The report compiled by the Ministry of Municipalities and Agriculture and SLR Consultants in their report entitled "Preparing an Integrated Waste Management Strategy for the Kingdom of Bahrain" in August 2005, concluded that of all the options available for waste treatment, the ones which provide the Best Practicable Environmental Option (BPEO) were:

- Initial Reception Area for pre-sorting/separation
- Separate re-cycling of the Construction Waste
- (composting of the source-separated green waste to energy to plant.
- Thermal treatment of the remaining waste and/or mcmte
- Landfill of the final residues which should account for no more than 10% by volume of the incoming waste stream."

(Ref. Tender documentation section 2.)
"The Ministry of Municipal Affairs and Agriculture in the Kingdom of Bahrain proposes to issue a Request for Quotation for the construction and operation on a Design Build Operate and Transfer ownership basis, (BOT) an Integrated Waste Management System for all the waste, excluding hazardous, toxic and medical waste arising in the Kingdom.

The key elements to the Project are:

- The plant should comprise initial reception area for pre-sorting/recycling, process for the treatment of domestic waste, Recycling of Construction Waste, composting of green and garden waste, thermal treatment plant for the elements no longer able to be re-used or recycled, and a sanitary solid waste landfill.
- The Integrated system should result in a high diversion of waste from the landfill
- The Contract period shall be 25 years from the date of commissioning
- The plant should be designed to accept un-sorted waste as the waste collection system operated by the Municipality does not allow for separation at source and therefore the recyclable materials are mixed with the putrescible, organic and other materials
- The selected contractor is required to lease or rent the proposed premises, site or land for establishing the waste treatment facilities, preferably in one of the Industrial Areas operated by the Ministry of Commerce and Industry. The site is to be strategically located in the country enabling efficient movement, transportation, disposal and treatment of waste without interference, obstructions and impacts and should pose no threat to the environmental resources and public health. The site needs to be accessible in all weather conditions, have sufficient lighting and should have a capacity for expansion and extension.
- The contractor is required to assess and provide all project permissions required for

the project, including planning, building, way-leaves, etc for the services and infrastructures. The Employer will assist in obtaining all permissions necessary for the selected site but the onus for completion will be with the Contractor.

- All components of the facility i.e. the reception, separation, domestic waste treatment, green waste composting, construction waste recycling, scrap cars treatment and thermal treatment, should be contained within the same boundary
- The existing municipal waste collection, transportation and handling system and operations should not be hindered. The proposed system should integrate the existing system.
- The risk for wastes to mix with the water/marine environment should be eliminated. The facility should not generate any obnoxious and hazardous odours.
- The location and operation of the facilities should not impact adversely on the local community and resources.
- The Contractor must provide an Emergency Procedures and Contingency Plan for the proposed waste treatment system.
- Comprehensive Quality Control and Health and Safety Plan must be incorporated into the tender submission.
- The location of the site will be south of GPIC Company as shown in Appendix A.
- The selected bidder shall consider in his business plan the reclamation of the land."

(Ref. Tender documentation Section 3.)

"The plant will have to meet the following criteria:

- Handle, treat and dispose of commercial and household waste using safe, efficient and environmentally friendly methods;
- facilitate the extension of the plants and the addition of new facilities;
- provide flexible operation to handle, treat and dispose of various wastes in quality and quantity and operate with maximum reliability and minimal downtime due to equipment and operation failure;
- comply with Kingdom of Bahrain standards and environmental regulations for all emissions (noise, odors, dust, solid matter, liquids, gases) emanating from any part al all of the waste treatment facilities;
- follow the BATNEEC principle (best available technology not entailing excessive costs);
- use commercially technically proven systems and procedures and ensure optimum utilization of energy, manpower and processes;
- incorporate high technology and advanced systems and set new standards for facilities of this kind in the Arabian Gulf region;
- comply with all national technical standards mentioned in the contract;
- provide a cost effective, economical basis concerning investment and running costs with minimal manpower in attendance;
- Utilize minimum amounts of water in the process. Water consumption will be a vital element in the choice of system and the tenderer must clearly indicate in his submission not only the amounts used by also from where this water will be derived;"

Our proposal can meet all the above criteria and fulfills all the requirements of the issuer, specified in the „Tender documentation".

C.4. Quality Control

The Facility must be built and operated to such a standard as to guarantee continuity of performance throughout the Contract Period, to maintain the levels of recycling and diversion of landfill throughout the period. The Contractor shall submit a Quality Control Plan to ensure compliance with construction and operation.

The TQM – Total Quality Management – system has been already developed and is readily available if our Proposal is ranked to the first place. The TQM system covers the entire project from the data collecting and design period, through the manufacturing and establishment until the operating of the whole plant, including with the security, healthcare, havaria and all other activities which are related to the complex waste management system.

The TQM secures and guarantees the highest quality level of the performance and operation of the TCG-UC Waste to Green Energy System in Kingdom of Bahrain. Due to the internationally accepted and agreed requirements this TQM system is both theoretically and practically tested and proved by several highly ranked company that are working on the World market.

C.5. Health and Safety

The Contractor shall submit a Health and Safety Plan which complies with all the safety regulations related to the Kingdom of Bahrain.

The contractor is to prepare and implement appropriate health and safety practices and measures at the site. The contractor"s staff should be trained in dealing with all emergencies and safety measures.

These Health and Safety Regulations Booklet will be completed during the final stage of the design period, due to necessity that we have to consider the technical and governmental requirements, and regulations.

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II. BASIC DATA OF THE PROJECT

Project initiation check list[2]

(Summary data-form of the Project)

0. Basic data of the project	
BIDDER	INTERNATIONAL TRADING HOUSE (S.P.C.)
CONTRACTOR	SYNERGY ENERGETICS TECHNOLOGICAL RESEARCH INVESTMENT CORPORATION.
PROJECT OWNER	MINISTRY OF MUNICIPALITIES & URBAN PLANNING, BAHRAIN
PROJECT NAME	PROVISION OF AN INTEGRATED WASTE MANAGEMENT SYSTEM
PROJECT COMPANY	SYNERGY & ITH JV (SYNERGY MIDDLE-EAST Spc)

1. Basic data of the project I.	
Name of Project	TCG-UC BAHRAIN Project
Location – City / Country	Askar Municipal Landfill Site / Kingdom of Bahrain
Type of Project	Design, Establishment and Operation of a TCG technology based, W2GE (Waste To Green Energy) system, utilizing MSW (Municipal Solid Waste) as feedstock
Industry and Technology	The syngas produced by the TCG Units through a near zero harmful gas emission process will be utilized in GTE Units to produce electricity and heat energy (**Exhibit 1.**)
Experience and Track Record	Industrial Scale TCG Power plants in Colorado and Ohio
The entitlements/authorities of the principals:	1. 2. 3.
Investor's consent **Permitting of a small power plant establishment**	
TCG-UC W2GE POWER PLANT SITE	
The Name and Place of the Landfill Site	**Askar Municipal Landfill Site** (Kingdom of Bahrain)

[2] This check list can be used for establishing the project's financing and financing mechanism and was made for the use by the investor(s) only. It must not be used for any other purpose.

Lot Number :	
Classification of the area	Industrial land
The size of the availabe lot/area :	230.000sq.m +330.000 sq.m
Land titles	Governmental land
PRE-SELECTION PLANT	**AUXS UNIT**
The site of the Pre-Selection Unit	**Askar AUXS 1** Site (Southern Site) (Kingdom of Bahrain)
Lot Number	
Classification of the area	Industrial land
The size of the availabe lot/area	6.000 sq.m
Land titles	Askar Municipal Landfill Site (Kingdom of Bahrain)
GASIFICATION PLANT	**TCG UNITS**
The site of the TCG Plant	Askar TCG Site (Northern Site) (Kingdom of Bahrain)
Lot Number	
Classification of the area	Industrial land
The size of the availabe lot/area	18.900 sq.m
Land titles	Askar TCG Site (Kingdom of Bahrain)
FINAL PRODUCT PLANT	**GTE UNIT**
The site of the GTE Plant	Askar GTE Site (Northern Site) (Kingdom of Bahrain)
Lot Number	
Classification of the area	Industrial land
The size of the availabe lot/area	9000 sq.m (+9000 sq.m)
Land titles	Askar TCG Site (Kingdom of Bahrain)
BYPRODUCT PLANT(S)	**BYPROD UNIT**
The site of the SILICA+DECOR Plants	Askar BYPROD Site (Southern Site) (Kingdom of Bahrain)
Lot Number	
Classification of the area	Industrial land
The size of the availabe lot/area	11.000 sq.m
Land titles	Askar TCG Site (Kingdom of Bahrain)
FEEDSTOCK MATERIAL	
Owner of the feedstock	Government of Kingdom of Bahrain
1. Input material /feed	MSW+
1. Location of input material	Askar Municipal Landfill Site

	(Kingdom of Bahrain)
2. Input material/feed	-
2. Location of input material	-

2. Basic data/information of the project II.	
A projection (pro-forma) showing the anticipated annual revenue and net income of the project for a minimum of three years period.	
Current financial statements are required from the principals or entity. Credit Score.	**CONTRACTOR**
Any investment of the Owner/Developer to date (amount).	NAP
Land and property	As contracted
Planning, Design and Infrastructure	1.920.000 EUR
Administration	750.000 EUR
Other expences	350.000 EUR

3a. Basic data of the feedstock/input material (s)

The calculation has been taking into consideration the following data, provided by the Ministry of Municipalities and Urban Planning of Bahrain: (**Ref. Tender documentation Sections 5.1. and 14.2**)

„However waste growth prediction is extremely difficult due to the range of influencing factors. Based on the adopted growth figures, waste arisings are predicted to rise from approximately 1,500,000 tonnes in 2008 to in excess of 2.7 million tonnes in 2030, with commercial, construction and domestic waste all experiencing significant growth."

(**Ref. Tender documentation Section 14.3**)

YEARLY 'TONNAGE ALL' REPORT FROM 2008 TO 2013

YEAR	DEAD ANIMAL	BUILDING WASTE	COMMERCIAL WASTE	DOMESTIC WASTE	GARDEN WASTE	INDUSTRIAL WASTE	TOTAL
2008	15329.3	617951.2	445508.2	380871.2	120189.1	65656.0	1,645,505
2009	16570.5	570455.8	320432.4	402241.2	149153.1	73672.6	1,532,526
2010	11643.4	528712.5	287511.1	457335.5	173128.4	87994.7	1,546,326
2011	9785.3	534473.5	247013.1	430836.1	117613.1	83566.9	1,423,288
2012	10585.02	476163.1	271245.9	444801.2	133999.7	95235.1	1,432,030
2013	9063.9	518919.4	268594.3	463859.7	151094.7	84016.8	1,495,549

(**Ref. Tender documentation Section 14.3**)

MONTHLY TONNAGE BY PRODUCT TYPE
YEAR - 2013

MONTH	DOMESTIC	COMMERCIAL	BUILDING WASTE	INDUSTRIAL	GARDEN	DEAD ANIMAL	TOTAL
	TONS	TONS	TONS	TONS	TONS	TONS	TONS
JANUARY	37194.2	23822.3	62263.1	9101.8	12364.9	317.8	145064.1
FEBRUARY	33212.8	20426.3	51875.1	7799.3	9704.4	201.2	123219.1
MARCH	38237.6	22507.9	37543.4	9286.7	12158.4	184.0	119917.8
APRIL	37651.4	23096.0	37850.9	7325.1	14025.4	197.5	120146.2
MAY	39718.0	22087.2	35328.1	7251.2	13444.2	594.6	118423.2
JUNE	39294.2	21494.5	34000.4	6672.8	12223.5	781.6	114467.1
JULY	42003.8	20554.7	31650.0	5787.6	10597.5	1389.9	111983.4
AUGUST	39211.3	22244.0	41520.3	5303.2	11417.1	1318.6	121014.5
SEPTEMBER	38088.7	24731.0	35316.2	5303.4	13743.3	1217.0	118399.6
OCTOBER	39422.0	23657.8	50647.5	5038.4	13811.6	1293.8	133871.2
NOVEMBER	40207.1	20600.6	57990.1	5973.6	12918.2	820.6	138510.2
DECEMBER	39618.6	23372.1	42934.1	9173.9	14686.3	747.4	130532.4
TOTAL	463859.7	268594.3	518919.4	84016.8	151094.7	9063.9	1495548.7

(**Ref. Tender documentation Section 14.3**)

Assumed Material Compositions of different Waste Streams

	Construction	Domestic	Commercial
	%	%	%
Paper	20.50%	12.79%	38.77%
Glass	3.90%	3.39%	4.94%
Metal	9.60%	2.05%	4.50%
Plastic	5.10%	7.44%	11.60%
Other Organic	0.00%	68.73%	26.59%
Inert	56.40%	0.00%	7.77%
Household Hazardous Waste	0.20%	0.19%	0.33%
Special Waste	4.10%	0.00%	4.54%
Mixed Residue	0.20%	5.40%	0.97%
TOTAL	100.00%	100.00%	100.00%

3b. Estimated quantity of MSW (Extrapolating on 2014 year data)

FACT	D	B	A	A	C	X	
	DEAD ANIMAL	CONSTRUCTION WASTE	COMMERCIAL WASTE	DOMESTIC WASTE	GARDEN WASTE	INDUSTRIAL WASTE	TOTAL
2013	9 063,9	518 919,4	268 594,3	463 859,7	151 094,7	84 016,8	1 495 548,8
%	0,61%	34,70%	17,96%	31,02%	10,10%	5,62%	100,00%

ESTIMATION	D	B	A	A	C	X	TOTAL	
2014	9 517,10	544 865,37	282 024,02	487 052,69	158 649,44	88 217,64	**1 570 326,24**	**TPY**
2015	9 992,95	572 108,64	296 125,22	511 405,32	166 581,91	92 628,52	1 648 842,55	TPY
2016	10 492,60	600 714,07	310 931,48	536 975,59	174 911,00	97 259,95	1 731 284,68	TPY
2017	11 017,23	630 749,77	326 478,05	563 824,36	183 656,55	102 122,95	1 817 848,91	TPY
2018	11 568,09	662 287,26	342 801,95	592 015,58	192 839,38	107 229,09	1 908 741,36	TPY
2019	12 146,49	695 401,63	359 942,05	621 616,36	202 481,35	112 590,55	2 004 178,43	TPY
2020	12 753,82	730 171,71	377 939,15	652 697,18	212 605,42	118 220,07	2 104 387,35	TPY
2021	13 391,51	766 680,29	396 836,11	685 332,04	223 235,69	124 131,08	2 209 606,72	TPY
2022	14 061,08	805 014,31	416 677,92	719 598,64	234 397,47	130 337,63	2 320 087,05	TPY
2023	14 764,14	845 265,02	437 511,81	755 578,57	246 117,34	136 854,51	2 436 091,40	TPY
2024	15 502,34	887 528,27	459 387,40	793 357,50	258 423,21	143 697,24	2 557 895,97	TPY
2025	16 277,46	931 904,69	482 356,77	833 025,38	271 344,37	150 882,10	2 685 790,77	TPY
2026	17 091,34	978 499,92	506 474,61	874 676,65	284 911,59	158 426,21	2 820 080,31	TPY
2027	17 945,90	1 027 424,92	531 798,34	918 410,48	299 157,17	166 347,52	2 961 084,33	TPY
2028	18 843,20	1 078 796,16	558 388,26	964 331,00	314 115,03	174 664,89	3 109 138,54	TPY
2029	19 785,36	1 132 735,97	586 307,67	1 012 547,55	329 820,78	183 398,14	3 264 595,47	TPY
2030	20 774,62	1 189 372,77	615 623,06	1 063 174,93	346 311,82	192 568,04	**3 427 825,24**	**TPY**

Briefly describe investment proposal / Short Executive Summary	NAP

4. Basic data of the feedstock/input material (s)	
Type	MSW
Input/feed as received quantity	Cca. 514 TPD / 1 Unit Cca. 3 086 TPD / 6 Units
Input/feed dry quantity	CCa. 500 sTPD = 454 TPD / 1 Unit Cca. 3 000 sTPD = 2 722 TPD / 6 Units

5. Basic data/ information of the end product (s)	
Final Product	Electricity and heat energy
Location of the network connection	AlDur Power Plant
Electric connection	AlDur Power Plant
Owner/operator of the electric connection point	AlDur Power Plant
Hrsz	
Selling price, Costs of the elements/units of system, Rent, Tariffs	Electricity: Cost f Electricity: 0,32EUR/kWh Purchase Price: 0,16 EUR/kWh Thermal Energy: NAP

6. Basic data/information of the Project-firm and the Owners	
Purchaser / Company	SYNERGY & ITH JV
Owners	NAP
Group of investor (s)	100%
Owner 2	%
General Projects Development Consultancy LLC.	First CONTRACTOR Middle-East W.L.L.
Technical Superviser	CONTRACTOR Energetics T.R.I. Corp.
TCG Technology provider	TCG GLOBAL LLC. and TCG Alena GmbH.
GTE Technology provider	TCG GLOBAL LLC. and TCG Alena GmbH.
AUXS Technology provider /	TCG ALENA GmbH. – LNDNRecyclIngtech GmbH
Permitting:	

7a. Basic technical data of the technology in case of ONE TCG UNIT	
Number of TCG-UC Units	1
Type of TCG-UC Unit	TCG-UC EL500TPD
BASIC DATA OF EACH UNIT	
Daily total quantity of feedstock (as received) (TPD)	514
Total energy applied (MJ/D)	6 235 135
Required energy from the energy generated (own energy) (MWe)	2.2
Saleable electric energy (MWe)	20.21
Saleable thermal energy (MWth)	15.66
Yearly saleable electric energy (MWeh/Y)	151 342
Yearly saleable thermal energy (GJ/Y)	422 245
Proposed Startup Date	**The end of 18th months from the date of 1st installment paid.**
Project Schedule of the Project	
Proposed Schedule of TCG Power Plants	
Project Operation/Commercial production Date	**End of 1st month after start-up**

7b. Basic technical data of the technology in case of 6 UNITS	
Number of TCG-UC Units	6
Name of TCG-UC Plant	TCG-UC EL1500TH-TPY
BASIC DATA OF THE SITE WITH 6 UNITS	

Daily total quantity of feedstock (as received) (TPD)	3 086,00
Total energy applied (MJ/D)	37 411 526
Required energy from the energy generated (own energy) (MWe)	12.00
Saleable electric energy (MWe)	121.24
Saleable thermal energy (MWth)	93.96
Yearly saleable electric energy (MWeh/Y)	908 071
Yearly saleable thermal energy (GJ/Y)	2 533 519
Proposed Startup Date	**The end of 18^{th} months from the date of 1^{st} installment paid.**
Project Schedule of the Project	
Proposed Schedule of TCG Power Plants	
Project Operation/Commercial production Date	**End of 1^{st} month after start-up**

8a. Basic financial data and information of ONE GTE UNIT	
Number of unit =1	**1 Unit**
Total input material (on as received basis) (TPD)	514,00
Total input energy (MJ/d)	6 235 254
Salable produced electric energy (MW_eh/h)	20.21
Salable heat energy ($MW_{th}h/h$)	15.66
Salable heat power (GJ/h)	56,38
Total investment requirement (BHD)	68 951 986 ,-
Labor cost (BHD/year)	3 239 010,-
Yearly operation cost (BHD/year)	9 958 435,-
Total income/revenue (BHD/year)	19 742 348,-
EBITDA (USD/year)	6 544 903,-

8b. Basic financial data and information of the Electricity Section	
Number of units=6	**6 Units**
Total input material (on as received basis) (TPD)	3 086,00
Total input energy (MJ/d)	37 411 526
Salable produced electric energy (MW_eh/h)	121,24
Salable heat energy ($MW_{th}h/h$)	93,96
Salable heat power (GJ/h)	338,26
Total investment requirement (BHD)	410 525 194,-
Labor cost (BHD/year)	16 673 159,-
Yearly operation cost (BHD/year)	61 092 000,-
Total income/revenue (BHD/year)	118 501 655,-
EBITDA (USD/year)	40 736 496,-

Rate of return (%)	7
Time of return of investment (year)	10,08

9. Project development schedule		
	Job	**Deadline**
	Completion date of project document (Approved)	February 27, 2015.
	Date of establishing the project-firm (Estimated time)	June 15, 2015.
	Filing date of permitting	September 15, 2015.
	1. Data reconciliation	February, 2015.

Projected Returns	***Estimate (in US$ or €)***
Financial projections, eg; ROI, IRR, NOI etc	
Maximum Loan Exposure	
Projected Payback Period	
Debt to Equity Ratio Proposal	

Borrower Investment	***$/€ Total***
Land & Property	
Planning, Design & Infrastructure	
Administrative	
Other expenses	
Total	

1. Goals, objectives to be accomplished

It is vital to establish a complex power plant in the Askar (Kingdom of Bahrain) region to eliminate or at least to a great extent reduce the acute problems and difficulties caused by the disposal and handling of enormous quantities of industrial, agricultural and community solid waste that are generated continuously.

The waste materials create an almost insurmountable difficulty in terms of inadequate capacity of existing landfill sites, no possibility to create new depots, as well as creating huge environmental and health hazards to the communities.

On the other hand, these waste materials contain large amounts of organic materials that can be used as a sustainable resource for energy generation. The recently-perfected Thermo-Chemical Gasification (TCG) technology is able to provide an unparalleled solution to remedy these problems by utilizing the waste material as feedstock to generate/manufacture synthetic gas with high efficiency and almost zero emissions, which can be utilized directly as fuel gas to generate electricity in gas motor/turbine generator set or itself further processed as a feedstock to produce hydrocarbons such as ethanol, methanol, bio-diesel or synthetic natural gas (SNG) through the application of the well-known Fischer-Tropsh catalytic converting system.

As it was written in the tender documentation issued by the Ministry of Municipalities, „*the Kingdom of Bahrain generates over 1,500,000 tons of waste per year which is presently disposed of at the Askar Municipal Landfill Site located in the quarry area in the south of the country.*

It is estimated that there are 23 million cubic metres of landfill space left, and the present infill rate of 1.7 cubic metres of space for each tonne of waste, and assuming an increase in growth of 5%, the Askar Landfill site will have been exhausted within 10 years.

The Kingdom of Bahrain, comprising of 36 islands with a total area of about 057 sq. km. is inhabited by a population of over 030,43777 with a population density of around 829 person/sq. km. The current population growth rate is around 3% with more than 80% of the population living in urban areas.

The land resources of Bahrain are very limited and needs to be strictly protected against any form of pollution, which might affect the finite environmental resources of the country. Bahrain"s environmental resources are considered to be very fragile due to its limited land availability.

The rapid industrialisation, population growth and increase in consumerism are causing significant increase in waste quantities which needs to be appropriately managed. Municipal waste treatment has now become a national concern mainly due to the enormous quantities and types of waste generated, limited municipal capabilities, nonavailability of land resources, occurrence of serious marine pollution and human health implications."

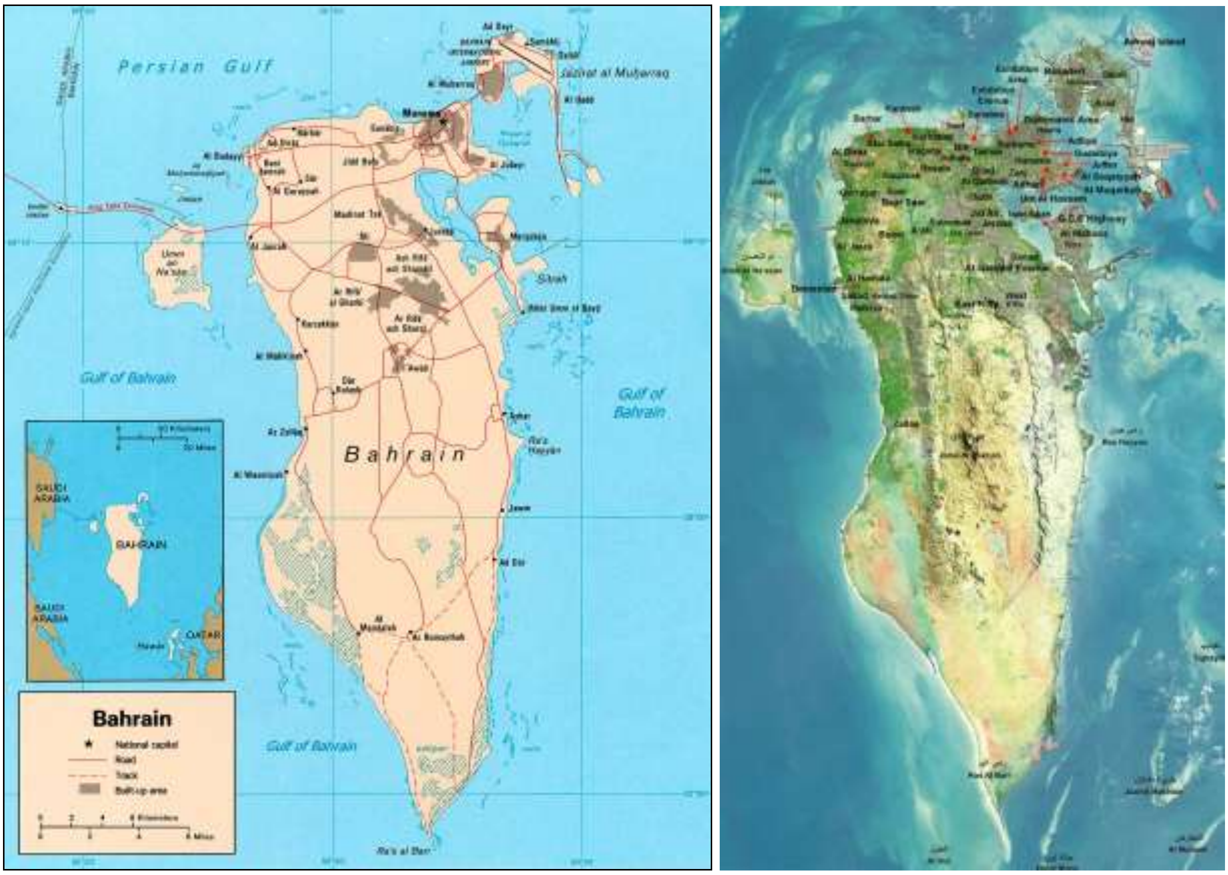


Figure 1.1. Bahrain

In the geomorphology map there can be seen clearly the two different regions of the island. The Northern part with its not so dry climate due to the airstreams with a little higher humidity from the sea, and the arid, Southern part with a very low rainfall and tipical desert climate.

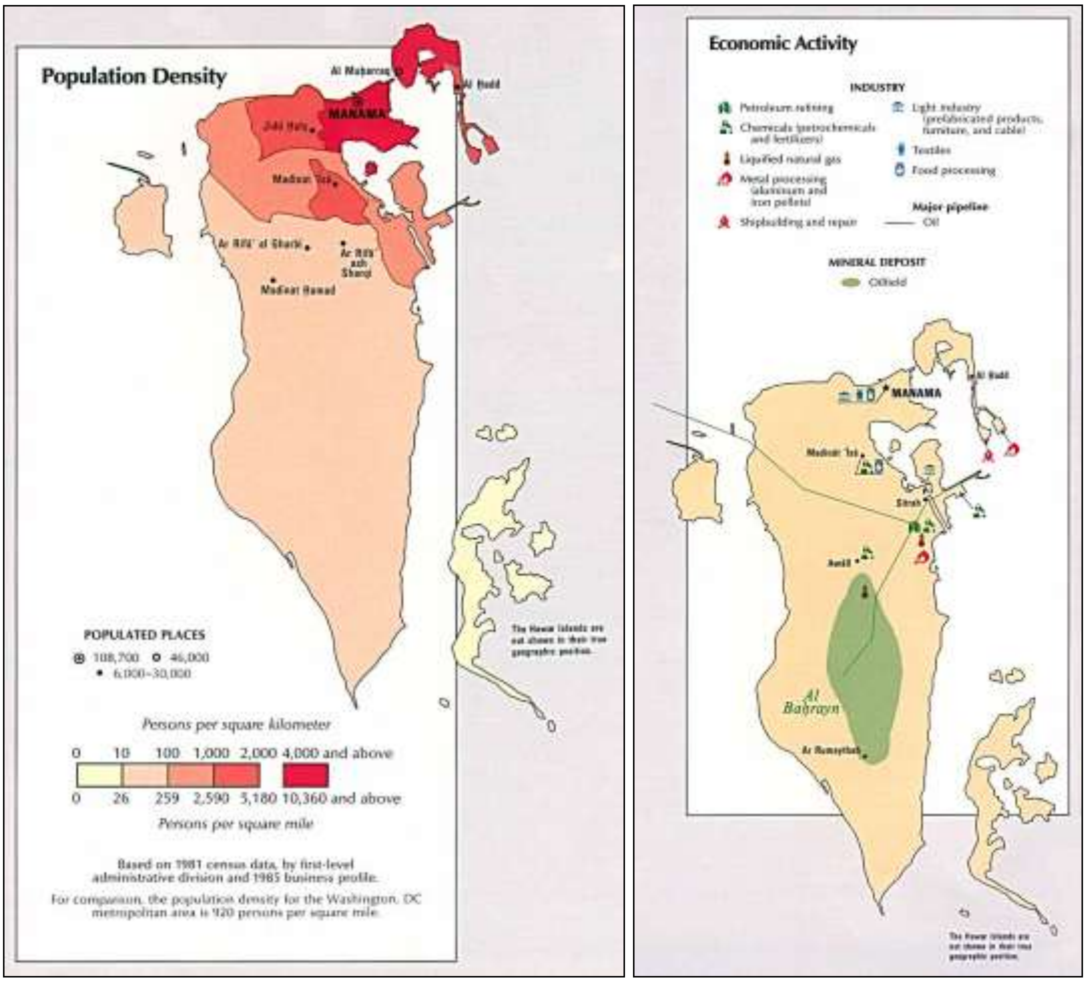


Figure 1.2. and 1.3. Population density and Economic activity of Kingdom of Bahrain

Figure 1.4. Manama city view

2. Summary information

2.1. Environment

2.1.1. Geography, geology

Around most of Bahrain is a relatively shallow inlet of the Arabian Gulf known as the Gulf of Bahrain. The seabed adjacent to Bahrain is rocky and, mainly off the northern part of the island, covered by extensive coral reefs. Most of the island is low-lying and barren desert. Outcroppings of limestone form low rolling hills, stubby cliffs, and shallow ravines. The limestone is covered by various densities of saline sand, capable of supporting only the hardiest desert vegetation – chiefly thorn trees and scrub. There is a fertile strip five kilometers wide along the northern coast on which date, almond, fig, and pomegranate trees grow. The interior contains an escarpment that rises to 134 meters, the highest point on the island, to form Jabal ad Dukhan (Mountain of Smoke), named for the mists that often wreathe the summit. Most of the country's oil wells are situated in the vicinity of Jabal ad Dukhan.

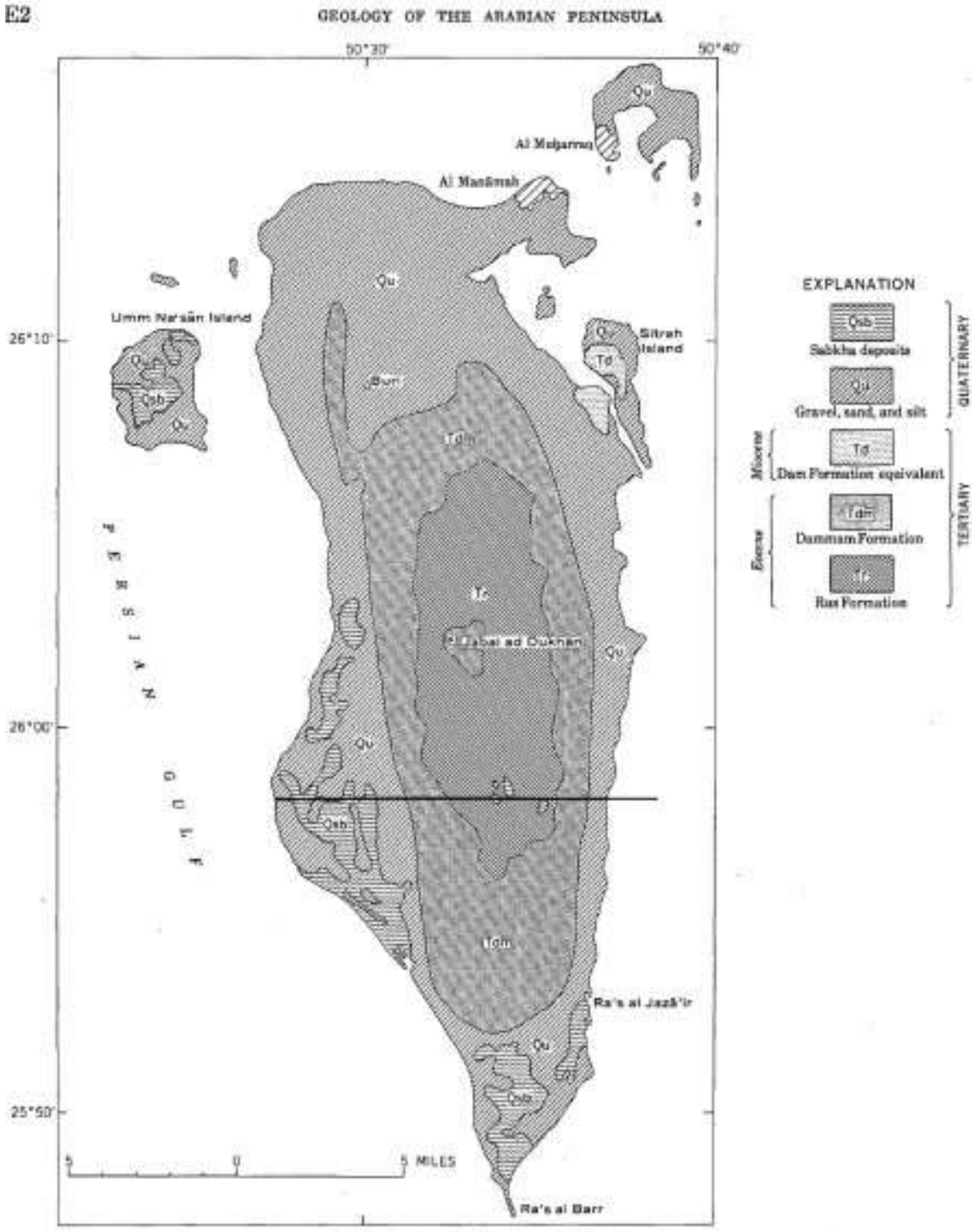


FIGURE 1.—Geologic map of Bahrain.

Figure 2.1.1.1. The temperature iso-lane map of the wider environment

As Faroughy, Abbas. wrote in 1951, in his "The Bahrein Islands" work (750-1951): (A Contribution to the Study of Power Politics in the Arabian Gulf. New York: Verry, Fisher & Co. Pages 14-15)

"Bahrein lies on a portion of the ancient Tethys Ocean geosynclinal belt represented today by the Arabian Gulf. The formation of the principal island is the result of pressure from the mountain masses of Persia against the crystalline platform of central Asia, the thrust being absorbed by gentle folding in the geosynclines.

The structure of Bahrein is that of a large, single, closed dome covering the entire faulting. Rocks exposed at the surface consist of: 1) Recent sands and coquinas forming flat, raised beaches surrounding the island from which the surface rises gradually to an elevation 150 to 200 feet above sea level. At this point it breaks away into inward-facing cliffs eighty to one hundred feet high completely surrounding an oval central depression about twelve miles long and four wide. 2) Pleistocene sands, cross bedded and probably wind deposited, lying in the canyon. 3) Miocene silicious clay covering a very limited area. 4) Eocene limestone covering most of the island, the central region of which, known as "Jabal Dukhār "Mountain of Smoke", rises to a point 439 feet above sea level. The limestone is very porous and is the source of most of the water in the northern half of the island."

Figure 2.1.1.2. The earthquake stations of Bahrain

Figure 2.1.1.3. Aerial view of the country

The site can be found 2-3 Km to South-West from Al Dur, and 1,5-2 Km to West from Al Dur power plant

Central coordinates are:

No.	ID of the No.		Coordinate		Coordinate
1	Northern Site	N	25º 58' 11.34"	E	50º 35' 46.24"
2	Southern Site	N	25º 57' 46,74"	E	50º 35' 40,79"

Figure 2.1.1.4. Aerial view of the region

Before decison of the exact site of the TCG power plant and the landfill plot, we have to consider the geographical and technical attributes of the environment.

1. The morphology of the island is simple. The highest point of the region is to south from the sites, so it doesn't influence the wind and hydrology environment.
2. Considering the W-SW wind direction and the odour of the wastes to be handled, the landfill plots must be established to S-SW direction from the Visitor Center and the Offices. (**Figure 2.1.5., Figure 2.1.6.)**
3. The GTE unit (s) must be established as close to the Al Dur power plant as possible, because on one hand the produced electricity is easily connected to the national grid through the transformator unit of the power plant and on the other hand, the electricity requested to operate the TCG-UC W2GE site, can be received from the Al Dur power plant as well. (**Figure 2.1.7.)**
4. It is obvious that on one hand, both the TCG Unit, and the GTE Unit of the TCG-UC Power Plant must be established on the Northern site, and on the other hand, the pre-selection plant and the landfill plots must be established on the Southern site. (**Figure 2.1.8.)**

2.1.2. Climate

Bahrain features an arid climate. Bahrain has two seasons: an extremely hot summer and a relatively mild winter. During the summer months, from April to October, afternoon temperatures average 40 °C (104 °F) and can reach 48 °C (118.4 °F) during June and July.

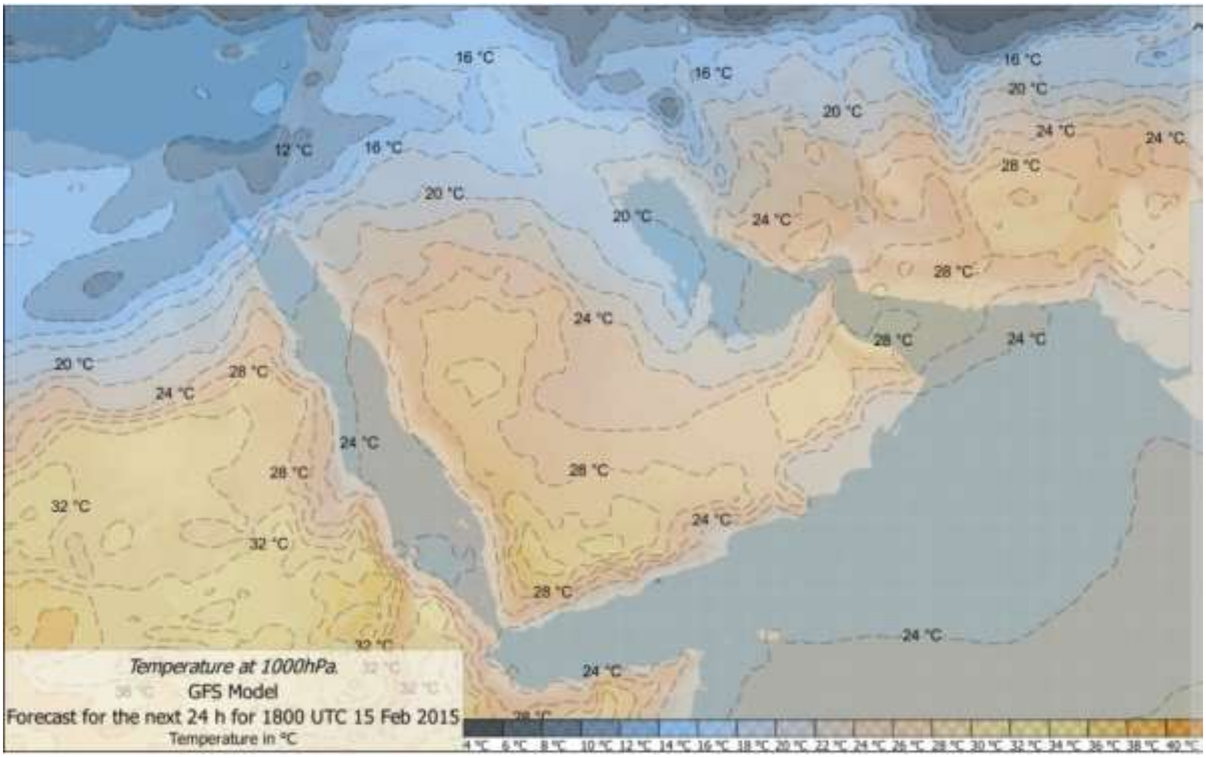


Figure 2.1.2.1. The temperature iso-lane map of the wider environment

The combination of intense heat and high humidity makes this season uncomfortable. In addition, a hot, dry southwest wind, known locally as the qaws, periodically blows sand clouds across the barren southern end of Bahrain toward Manama in the summer. Temperatures moderate in the winter months, from November to March, when the range is between 10 and 20 °C (50 and 68 °F).

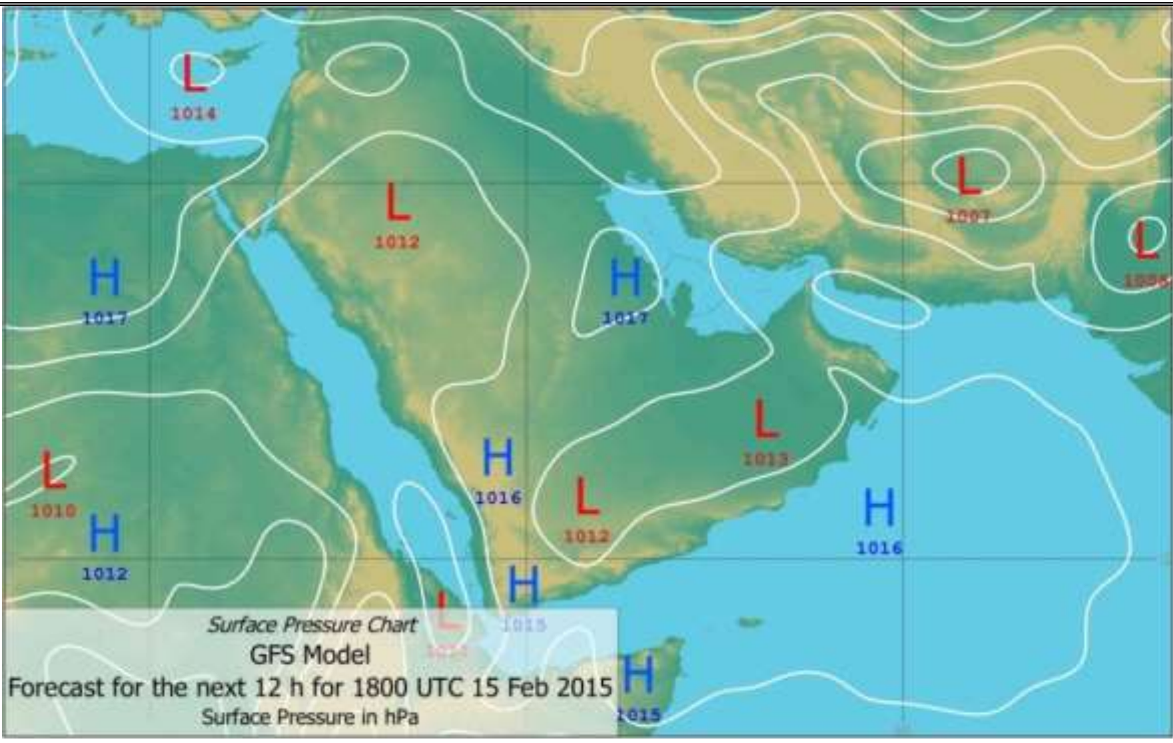
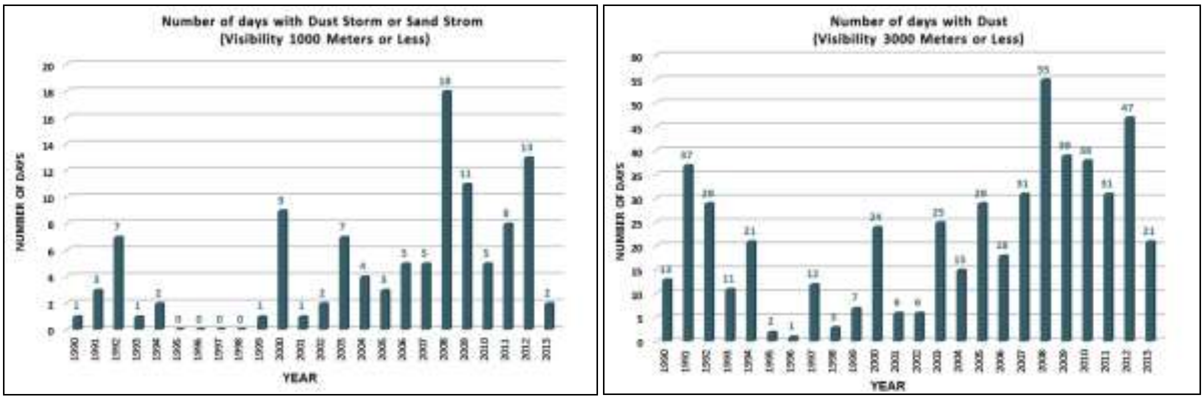


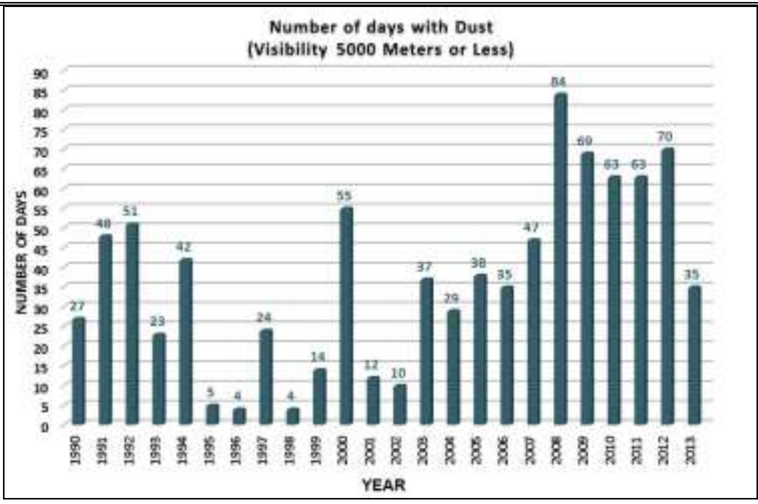
Figure 2.1.2.2. The Surface Pressure iso-lane map of the wider environment

Outside of Manama, urban development exists in the central northern area of the main island (Isa Town & Hamad Town).

Important regional features are the dust and sand basins of Iraq some 350 nautical miles to the north west and the mountain range of the Zagros of Iran, 120 nautical miles at their nearest to the north east. These features, together with the Gulf waters have the main influence on the broadscale climate of Bahrain. The Zagros hills cause the low level winds to be directed to below mainly from the north west or south east by steering or influence on the pressure pattern. The dust bowls of Iraq and northern Saudi Arabia provide an abundance of fine dust particles easily transported by north westerly winds which cause visibility reductions at Bahrain, mainly in the months of June and July. The Gulf waters provide a low level moisture supply.



a b



c

Figure 2.1.2.3. a, b, c, The number of Sand Storm or Dust Storm (Visibility is a:1.000m; b:3.000m; c:5.000m)

Seas are relatively shallow around Bahrain and heat up quickly in the summer to give high dew point values and humidity, especially at night. Sea temperatures may reach 35 Degrees Centigrade during the summer.

However, humidity often rises above 90% in the winter. From December to March, prevailing winds from the southeast, known as the shamal, bring damp air over the islands. Regardless of the season, daily temperatures are fairly uniform throughout the archipelago.

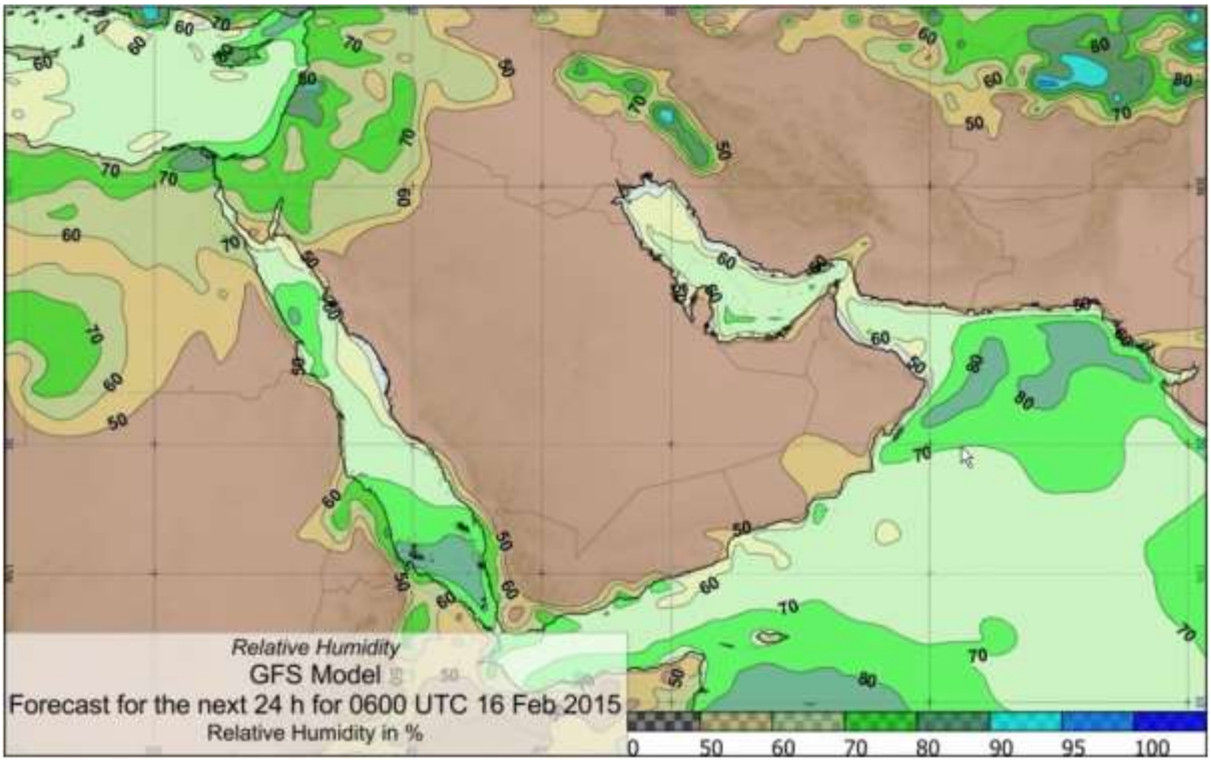


Figure 2.1.2.4. The Relative Humidity iso-lane map of the wider environment

2.1.2.1. The Winter Period

The winter period is the season of changeable weather when low pressure disturbances with their associated fronts transit the mid Gulf. Surface winds alternate mainly between south east ahead of these features and north west behind.
The passage of the front and troughs may be accompanied by thunderstorms and squalls. Isolated severe storms can occur. Between these periods of "weather" a high pressure ridge over and good visibility.

2.1.2.2. The Summer Period

The summer period is one of mainly cloudless skies and persistently high temperatures. A shallow dome of relatively cool moist air over the Gulf is overlaid by hot dry air causing a marked temperature inversion in the first 1000 to 1500 feet of the order of 5 to 10 Degrees Centigrade. The seasonal rise in temperature peaks in August with a mean daily maximum of 38.0 Degrees Centigrade. The extreme maximum temperatures are observed however in May (46.7 C). During June and July a period of persistently strong north westerly winds known locally as the "summer shamal" occurs and arrests temporarily the seasonal rise in temperature.
This shamal which is part of the Indian monsoon circulation is related directly to a low level jet stream concentrated near 1000 feet. This causes marked wind shears at times in the boundary layer of the order of 5-8 knots per 100 feet.
The shamal transports dust from Iraq and visibility at Bahrain on occasions is reduced to less than 1500 metres over this period mainly between 2000Z to 0600Z.

2.1.2.3. The Transition Period

The transition periods are important in two respects, the first is the abruptness of the change during October/November when first incursions of cool air from the north west occur and replace the quiet conditions of late summer. The second, and more importantly, is the spring transition.
This period is known as the sarrayat. Sudden changes in wind can occur, caused by relatively weak instability features, and low level wind shear has been observed with these sudden changes.

Bahrain receives little precipitation. The average annual rainfall is 72 millimeters (2.8 in), usually confined to the winter months. No permanent rivers or streams exist on any of the islands. The winter rains tend to fall in brief, torrential downpours, flooding the shallow wadis that are dry the rest of the year and impeding transportation. Little of the rainwater is saved for irrigation or drinking.

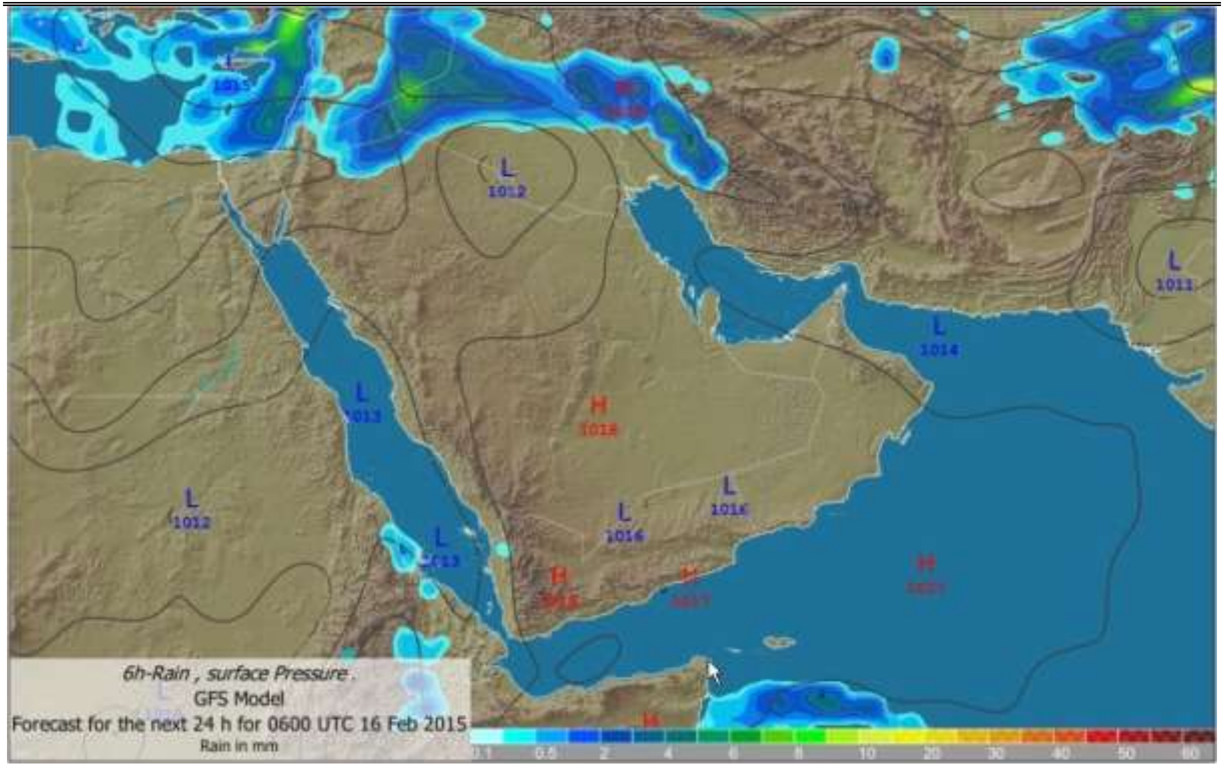


Figure 2.1.2.3.1. The Rain, Surface Pressure iso-lane map of the wider environment

However, there are numerous natural springs in the northern part of Bahrain and on adjacent islands. Underground freshwater deposits also extend beneath the Arabian Gulf to the Saudi Arabian coast. Since ancient times, these springs have attracted settlers to the archipelago.

Despite increasing salinization, the springs remain an important source of drinking water for Bahrain. Since the early 1980s, however, desalination plants, which render seawater suitable for domestic and industrial use, have provided about 60% of daily water consumption needs.

Climate data for Bahrain International Airport

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Record high °C (°F)	29.0 (84.2)	34.7 (94.5)	38.0 (100.4)	41.0 (105.8)	46.7 (116.1)	45.7 (114.3)	45.6 (114.1)	44.0 (111.2)	42.8 (109)	41.4 (106.5)	35.0 (95)	29.2 (84.6)	46.7 (116.1)
Average high °C (°F)	20.0 (68)	21.2 (70.2)	24.7 (76.5)	29.2 (84.6)	34.1 (93.4)	36.4 (97.5)	37.9 (100.2)	38.0 (100.4)	36.5 (97.7)	33.1 (91.6)	27.8 (82)	22.3 (72.1)	30.1 (86.2)
Daily mean °C (°F)	17.2 (63)	18.0 (64.4)	21.2 (70.2)	25.3 (77.5)	30.0 (86)	32.6 (90.7)	34.1 (93.4)	34.2 (93.6)	32.5 (90.5)	29.3 (84.7)	24.5 (76.1)	19.3 (66.7)	26.52 (79.73)
Average low °C (°F)	14.1 (57.4)	14.9 (58.8)	17.8 (64)	21.5 (70.7)	26.0 (78.8)	28.8 (83.8)	30.4 (86.7)	30.5 (86.9)	28.6 (83.5)	25.5 (77.9)	21.2 (70.2)	16.2 (61.2)	23.0 (73.4)
Record low °C (°F)	2.7 (36.9)	7.9 (46.2)	10.9 (51.6)	10.8 (51.4)	18.7 (65.7)	22.7 (72.9)	25.3 (77.5)	26.0 (78.8)	24.4 (75.9)	18.8 (65.8)	13.5 (56.3)	6.4 (43.5)	2.7 (36.9)
Precipitation mm (inches)	14.6 (0.575)	16.0 (0.63)	13.9 (0.547)	10.0 (0.394)	1.1 (0.043)	0 (0)	0 (0)	0 (0)	0 (0)	0.5 (0.02)	3.8 (0.15)	10.9 (0.429)	70.8 (2.787)

Avg. precipitation days	2.0	1.9	1.9	1.4	0.2	0	0	0	0	0.1	0.7	1.7	9.9
Mean monthly sunshine hours	226.3	221.2	238.7	255.0	306.9	339.0	331.7	331.7	312.0	303.8	261.0	226.3	3,353.6

Source: NOAA (1961-1990) [2]

Table 2.1.2.3.1. Climate data for Bahrain International Airport

Figure 2.1.2.3.2. The wind map of the region

Bahrain - Bahrain (Yacht Club) [Beállítások]

Előrejelzés | 2D | Térkep | Webkamera | Szél jelentés | Szállás | Iskola/Bérlés | Boltok | Egyéb...

GFS 50 km 13.11.2014 00 UTC	CS 13. 03h	CS 13. 06h	CS 13. 09h	CS 13. 12h	CS 13. 15h	CS 13. 18h	CS 13. 21h	PÉ 14. 03h	PÉ 14. 06h	PÉ 14. 09h	PÉ 14. 12h	PÉ 14. 15h	PÉ 14. 18h	PÉ 14. 21h	SZ 15. 03h	SZ 15. 06h	SZ 15. 09h	SZ 15. 12h	SZ 15. 15h	SZ 15. 18h	SZ 15. 21h	VA 16. 03h	VA 16. 06h	VA 16. 09h	VA 16. 12h	VA 16. 15h	VA 16. 18h
Szél sebesség (csomó)	4	3	2	2	6	7	8	6	4	2	4	8	9	9	7	6	5	4	7	9	8	4	3	3	1	5	7
Széllökés (csomó)	4	4	3	3	6	8	8	6	6	5	6	9	10	9	7	6	6	4	6	8	8	3	3	2	2	4	7
Szélirány	↙	↙	←	↙	↙	↙	←	↖	↖	←	↙	↙	↙	←	↖	←	←	←	↙	↙	↙	←	↖	↖	↖	↙	↙
*Hőmérséklet (°C)	24	24	24	25	25	26	26	25	25	25	26	27	27	27	26	26	26	26	27	26	26	25	25	25	26	26	26
Felhőtakaró (%)	-																									23	
magas / közép / alacsony	-												8														
*Csapadék (mm/3ó)	-																										
Windguru értékelés																											

GFS 50 km 13.11.2014 00 UTC	VA 16. 21h	HÉ 17. 03h	HÉ 17. 06h	HÉ 17. 09h	HÉ 17. 12h	HÉ 17. 15h	HÉ 17. 18h	HÉ 17. 21h	KE 18. 03h	KE 18. 06h	KE 18. 09h	KE 18. 12h	KE 18. 15h	KE 18. 18h	KE 18. 21h	SZ 19. 03h	SZ 19. 06h	SZ 19. 09h	SZ 19. 12h	SZ 19. 15h	SZ 19. 18h	SZ 19. 21h	CS 20. 03h	CS 20. 06h	CS 20. 09h	CS 20. 12h	CS 20. 15h
Szél sebesség (csomó)	7	7	7	7	4	5	10	13	9	9	8	5	4	8	11	5	4	3	4	7	8	8	11	11	10	10	11
Széllökés (csomó)	7	7	7	7	5	5	10	13	10	9	9	6	4	9	10	5	3	3	4	7	9	8	11	12	10	10	11
Szélirány	←	↖	↑	↑	↑	←	←	↖	↑	↑	↑	↗	←	←	←	↑	↗	→	↓	↙	↙	↓	↓	↓	↓	↓	↓
*Hőmérséklet (°C)	26	25	25	25	26	27	27	27	26	25	25	27	28	27	27	26	25	26	26	26	26	26	26	26	26	26	26

Table 2.1.2.3.3. The wind journal of Bahrain Yacht Club

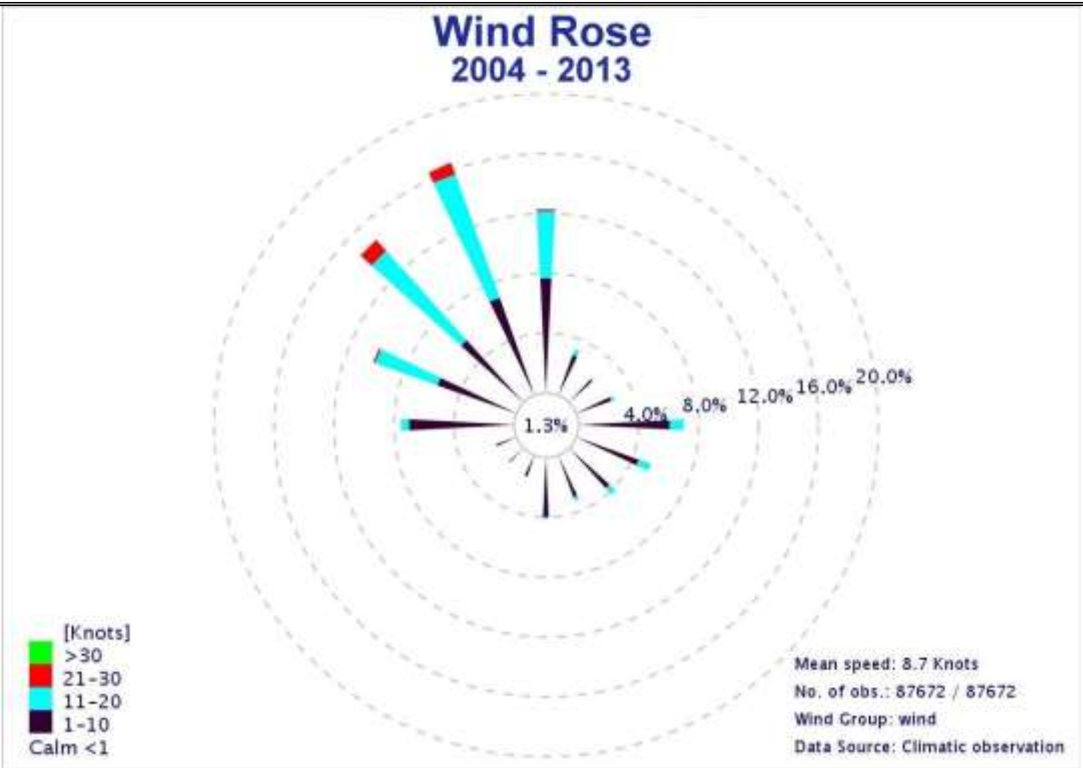


Table 2.1.2.3.4. The Wind Rose of Bahrain

Figure 2.1.2.3.5. The Al Dur Power Plant

2.1.3. Water resources, groundwater

The total annual surface runoff is only about 4 million m^3 and there are no perennial streams. Bahrain receives groundwater by lateral under-flow from the Damman aquifer, which forms only a part of the extensive regional aquifer system, called the Eastern Arabian Aquifer. This aquifer extends from central Saudi Arabia, where its main recharge area is located at about 300 meters above sea level, to eastern Saudi Arabia and Bahrain, which are considered the discharge areas. The rate of groundwater inflow has been estimated at about 112 million m/year under steady-state conditions (before 1965) and this figure is considered to be the safe groundwater yield in Bahrain. There are no dams in Bahrain.

2.2. Specific data of the site

The Sheikhdom of Bahrain is a group of islands in the Arabian Gulf between the Qatar Peninsula and Saudi Arabia.
The discovery well was completed as a producer from the middle Cretaceous in June 1932. The principal outcropping rocks on Bahrain, the main island, are of Eocene age, with Miocene and younger rocks on the periphery. The anticlinal structure is clearly discernible in the rimrock that encircles the central part of Bahrain Island.

The Sheikhdom of Bahrain (Fig. 2.2.1.) consists of a group of low-lying islands between the Qatar Peninsula and Saudi Arabia at approximately lat 26° N., long 50°30' E. The 1nain island of Bahrain is about 48.3 kilometers (30 1niles) long and 16.1 kilometers (10 miles) wide and reaches a maximum altitude of 134.1 meters (440 ft) at Jabal ad Dukhan near its geographical center. The principal subsidiary islands are: Al Muharraq and Sitt·ah to the northeast, U mm *N* a'san to the west, and Juwar to the southeast near the Qatar coast. Numerous other small islands are within the Bahrain territorial boundary.

The geology of Bahrain was first mentioned in 1908 in a memoir by Guy S. Pilgrim, Indian Geological Survey, on the geology of the Arabian Gulf region. This study was followed in 1928 by private work by R. 0. Rhoades of the Gulf Oil Corp. The discovery well was drilled in 1931-32 by the Standard Oil Co. of California and was completed as a producer from the middle Cretaceous in June 1932. The present rate of oil production is 45,000 barrels per day from 165 wells.
Acknowledgments are made to the Bahrain Petroleum Co., Ltd., and American Overseas Petroleum Ltd., for permission to publish this discussion, and to those who, in the past, contributed numerous reports to the company files on the geology of Bahrain. These reports were drawn on extensively during the preparation of this report.

2.2.1. Stratigraphy - General

The principal outcropping rocks on Bahrain Island are of early and middle Eocene age, with Miocene and younger rocks evident along the periphery. Recent deposits are concentrated in the southern and southwestern parts of the island in the Ra's al Barr and Ra's al J aza'ir areas. Eocene and Miocene rocks are also exposed in the Huwar Islands to the southeast, but the other small islands of the Bahrain Group are limited to Pleistocene (?) and Recent deposits, with the exception of Umm Na'san, which appears to have some Miocene deposits.
The dominant rock types within the Eocene and Miocene of Bahrain are limestone, dolomitic limestone, and chalk, with subsidiary marls and shales.

Evidence of wind sculpturing can be seen throughout the islands; erosional remnants and striations have a predominant north-northwesterly orientation. A prominent topographic feature of Bahrain is the rimrock of Eocene limestone which forms a complete ring around the central part of the island. This rimrock in some places supports a cliff-face in excess of 30.5 m (100ft).

The only water gap is on the west.
An angular unconformity is indicated between middie Eocene and younger rocks by variations in thickness of the uppermost Eocene unit and by a change in lithology of the Miocene rocks to a 1nore sandy appearance.
The major basin of deposition during Eocene time appears to have been north-northwest of Bahrain in the Al Burqan-As Saffaniyah area, but the Miocene trough was farther to the east.

The Bahrain area is near the eastern edge of the Arabian Shelf, which was fairly stable.
The prevalent environment of deposition was shallow water that was normal marine to restricted marine. Sedimentation was typical of a Shelf area, and individual units extended for great distances laterally.

2.2.1.1. Lower Eocene-Rus Formation

The type section of the Rus Formation is· in the Ad ·Damman area of Saudi Arabia, and it is approximately 56.1 m (184 ft) thick. This is the oldest formation outcropping on Bahrain, and it occurs only in the central part of Bahrain Island within the rimrock area, where it reaches a total thickness (surface and subsurface) of about 67.1 m (220ft). The exposed part of this formation consists principally of chalk- and chert-ben.ring dolomitic limestones.
N uinerous quartz geodes can be found in many localities and a few have been known to contain petroleum. The only other surface indication of the presence of hydrocarbons is an inactive oil seep in the south-central part of the island on a possible fault trend.

Some anhydritic beds have been observed in the Rus Formation; erratic dips plus the existence of closed topographically low areas and lost circulation in all drilling operations suggest that much of the erosion within the rimrock area has been magnified by slumping of the strata above anhydritic beds that are probably leached.

The base of the Rus Formation is not exposed on Bahrain, but information derived from drilling indicates that the contact with the underlying Umm er Radhuma Formation is conformable.
Little or no paleontologic work has been done on the Eocene and younger rocks of Bahrain, but similar stratigraphic position and lithology have made possible a close correlation with Saudi Arabia to the west.
The Rus Formation on Bahrain is termed the "Zone C aquifer" and is the source of a limited supply of fresh water, the product of local rains, that floats on top of the usually saline water of the formation. The thickness of this fresh-water "cap" may reach 3-4.6 m (10-15ft) in some localities.
The limestones of the Rus are used extensively in the production of lime for the local construction industry.

2.2.1.2. Lower or Middel Eocene Dammam Formation Sharks Tooth Shale

The basal sharks tooth shale member of the **Dammam Formation** immediately overlies the "chalky beds" of the Rus Formation and averages between 9.1 and 15.2 m (30-50ft) in

thickness. It consists of gray to yellow shale and marl and subsidiary thin dolomitized lime stones.
The name given to this interval is derived from the lowest clay-shale bed, in which fossil shark teeth have been found. The upper part of the member is sometimes referred to as the Alveolina zone. The sharks tooth shale member is believed to correlate with the Midra Shale of Saudi Arabia.

2.2.1.3. Brown Crystalline Limestone

The brown crystalline limestone member of the Dammam Formation averages 33.5 m (110ft). in thickness. Tho rock is brown to buff massive hard 'porous finely crystalline dolomitic limestone. The lower part contains bands of nodular chert which may be largely responsible for the development of the rimrock that surrounds the central basin of the island. The upper contact with the overlying orange marl is sharp and conformable.
The brown crystalline limestone member of Bahrain is correlated with the Khobar Member *qf* Saudi Arabia, and is the main fresh-water aquifer of Bahrain; it carries the designatimi of "Zone B aquifer." Salinity increases and static head decreases to the southeast.

2.2.1.4. Orange Marl

The orange marl unit serves as an impermeable barrier between the overlying Zone A and underlying Zone B aquifers, and is easily recognized in drilling operations by its distinctive color and i'ts rather sharp contacts with contiguous members. The thickness ranges Lrom 6.1 to 19.8 m (20-65 ft), the average being approximately 12.2 m (40 ft) .

The rock consists of limonite-stained yellow-orange and brown slightly dolomitic marl; some thin marly limestone is interbedded in the upper part. The equivalent unit in Saudi Arabia is the Alat Marl.

2.2.1.5. White Limestone

The white limestone, designated the "Zone A aquifer," ranges from 6.1 to 62.5 m (20-205 ft) in thiclmess. Pronounced thickening is noted downdip beneath the Eocene-Miocene unconformity.
This upper member of the **Dammam Formation** is composed of white very porous finely crystalline commonly chalky and in part dolomitized limestone, and is correlated with the Alat Limestone on the Arabian Peninsula.
Local silicification of the limestone at the surface has resulted in a resistant layer in the form of a prominent scarp in the Biiri area of Bahrain Island and prominent cliffs along the shore of Huwar Island.

The white limestone is a major source of fresh water on Bahrain; however, as is true of the Zone B aquifer, the static head decreases to the southeast and the salinity increases, so that in the southern half of the island, practically no fresh water is available from these aquifers.·

2.2.1.6. Miocene

No formal names have been given to the Miocene and younger rocks on Bahrain. The Miocene comprises a sequence of clay, marl, shale, and sandy limestone and ranges in thickness from 0 to almost 61 m (200ft). An abrupt increase in thickness is noted down flank on the Bahrain anticline.

The basal unit of the Miocene is generally a thin sandy limestone and is considered as part of the Zone A aquifer, whose main component is the underlying white limestone of Eocene age. The thin sandy limestone is overlain by approximately 21.3 m (70ft) of soft gray clay and shale, which in turn is overlain by light-colored soft porous sandy limestone and mad. Miocene out crops of cream to brown limestone and marl have been recognized on Umm Na'san.

Crossbedded calcareous sandstone composed of masses of Milliolidae occurs at several localities on Bahrain and adjacent islands; it has been considered by some workers to be Miocene and by others to be as young as Pleistocene.

On Huwar Island a calcareous sandstone overlying known Eocene strata has been described. On Umm Na'san Island a similar sandstone is seen to rest unconformably on the Miocene beds, and on Bahrain such sandstone occurs in gaps in the rimrock, resting unconformably on the Eocene strata. These sandstones 1 are believed to be old dune deposits.

The Miocene of Bahrain is believed to be the equivalent of the Dam and Hadrukh Formations of Saudi
Arabia and the Lower Fars of Iran.

2.2.1.7. Recent

Recent beach sands are found on all islands of Bahrain, but the most noteworthy deposits occur on Bahrain Island in the Ra's al J aza'ir and Ra's al Barr areas.

In these areas extensive salt flats and marshes (Sabkha deposits) make any surface operations extremely difficult. Beachsand deposits have not been mapped in detail and, as a result, it has not been possible in figure 1 to differentiate them from other unconsolidated surficial deposits of gravel, sand, and silt that cover extensive parts of the islands.

There is also much evidence of Recent limestone and calcareous-mud deposition in the shallow near-shore water of Bahrain; much of this limestone is used in local construction work.

2.2.2. Structure

Bahrain is on the Interior Platform (Rasa Structural Terrace), which is a prominent feature of the Arabian Peninsula; the formation of individual structures appears to have resulted from vertical uplift rather than compressive stresses. The only evidence that compressive stresses were active at all is the somewhat steeper west flank of the Bahrain anticline.

The Bahrain anticlinal axis is oriented in a north-south direction and the structure is fairly simple-no faults visible at the surface. Most faults observed in the subsurface have displacements of less than 15.2 m (50ft), and all are classified as normal tension faults.

Early Eocene time was characterized by a shallow-water restricted marine environment as indicated by the presence of anhydrite in the Rus Formation. Increased subsidence during middle Eocene time brought more normal marine conditions, and limestone and shale were deposited. Local and regional uplift near the close of middle Eocene initiated a period of erosion in the Bahrain area, and no upper Eocene or Oligocene sediments have been recognized. Continued local uplift exceeded the regional tilting, and Miocene sediments were deposited in the relatively low areas around the main anticline, unconformably onlapping the Eocene deposits.

Further local uplift in the late Miocene and Pliocene caused erosion of some of the Miocene sediments and gave the islands their present configuration.
Recent beach-sand accumulations added the flat salt marsh areas in the south and southwest parts of the main island. The post-Eocene uplift made possible the leaching of anhydrite from the Rus Formation, and the leaching caused slumping along the structural axis.
This slumping, together with the pr·evailing northerly winds, completed the geologic sculpturing of Bahrain.

E2 GEOLOGY OF THE ARABIAN PENINSULA

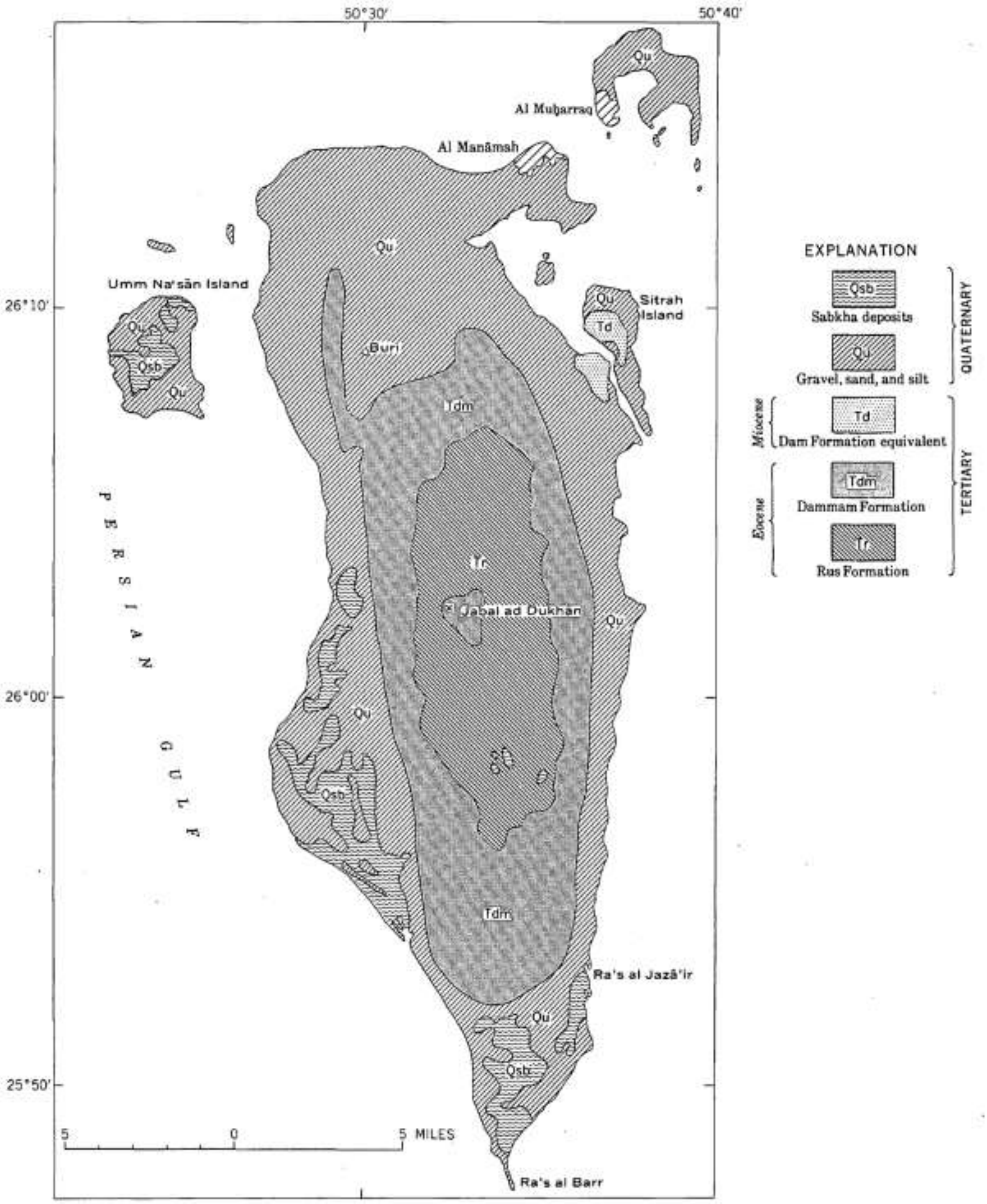


FIGURE 1.—Geologic map of Bahrain.

Figure 2.2.2.1. Geologic map of Bahrain

Figure 2.2.2.2. Aerial view I.

Figure 2.2.2.3. NW corner of the Northern site

Figure 2.2.2.4.

2.2.2.1. Geodesical coordinates

To be determined in a later stage during the performance period of the Feasibility Study

No.	ID of the No.		Coordinate		Coordinate
1		N		E	
2		N		E	
3		N		E	
4		N		E	
5		N		E	
6		N		E	
7		N		E	
8		N		E	

Table 2.2.2.1.1. The geodesical coordinates of the significant points of the parts of the landfill site

2.2.2.2. Morphology

The surface of the landfill site is simple plane with maximum 10-18 m high hillocks and 20-70 cm high ridges from sand and fine silica dust. The mainly silica dust and wind-blown (eolic) sand gives the surface forms on the bigest part of the landfill area.

Figure 2.2.2.2.1. Highest point of the Southern part of the site

2.2.2.3. Climate parameters

The general climate of the small archipelago of Bahrain is **desert**, mild in winter and very hot in summer.

Basically there are two main seasons: a cooler season from December to mid-March, and a hot season from April to October, in which we can distinguish a very hot period from June to September.
Due to the influence of sea, the temperature range between night and day is low, and the humidity is high, except when the winds blow from the interior of Arabia.

In **winter**, from December to mid-March, temperatures are pleasant, especially in December and March, when lows are around 61/64 °F (16/18 °C) and highs are around 72/76 °F (22/25°C). The sun often shines, and the rains are scarce and rare. At times there can be even warm days, with peaks at around 86 °F (30 °C), when the winds blow from the south, but in these months this winds are rare.

In mid-winter, in January and February, temperatures are a bit lower, so that highs are around

68/70 °F (20/21 °C); sometimes a cold air mass from the north can lower the daytime temperature to around 59 °F (15 °C), and that of the night to around 50 °F (10 °C). **Summer** in Bahrain is very hot and sunny, with highs around 98/100 °F (36/38 °C) from June to September, but they can easily reach 104 °F (40 °C); lows are around 84/88 °F (29/31 °C) from June to September, and the humidity from the Persian Gulf makes the heat unbearable. However, hotels, offices and restaurants are equipped with air conditioned. Here are the average temperatures of the capital Manama.

The prevailing **wind** in Bahrain is the *Shamal*, which is moist and blows from the north-west, more frequently in the summer months. Another wind, hot and dry, the *Qaws*, can blow throughout the year, but preferably in spring; it blows from the south and it's able to raise the temperature to about 86 °F (30 °C) in winter and about 104 °F (40 °C) and above from April to October, while drastically lowering the humidity, in addition to causing dust storms and sand.

As mentioned, the climate in Bahrain is desert, in fact just 2.8 inches (70 millimeters) of **rain** per year fall; most of the rains occur in the winter months, however, they are are irregular, and occasionally in winter there can be some intense rainfalls, which, being concentrated in a few hours, can cause flash floods.

Unlike other Gulf emirates, in Bahrain there are ancient springs of fresh water, but nowadays even here more than half of the fresh water consumed is obtained by seawater desalination.

The climate of the southern part of the island, where the site can be found, is arid desert climate in most time of the year. It is difficult to classify in the climate classification system – see bellow – due to the Saudi Arabian huge, real dry and hot desert, and the Arabian Gulf evaporation and cooling effect.

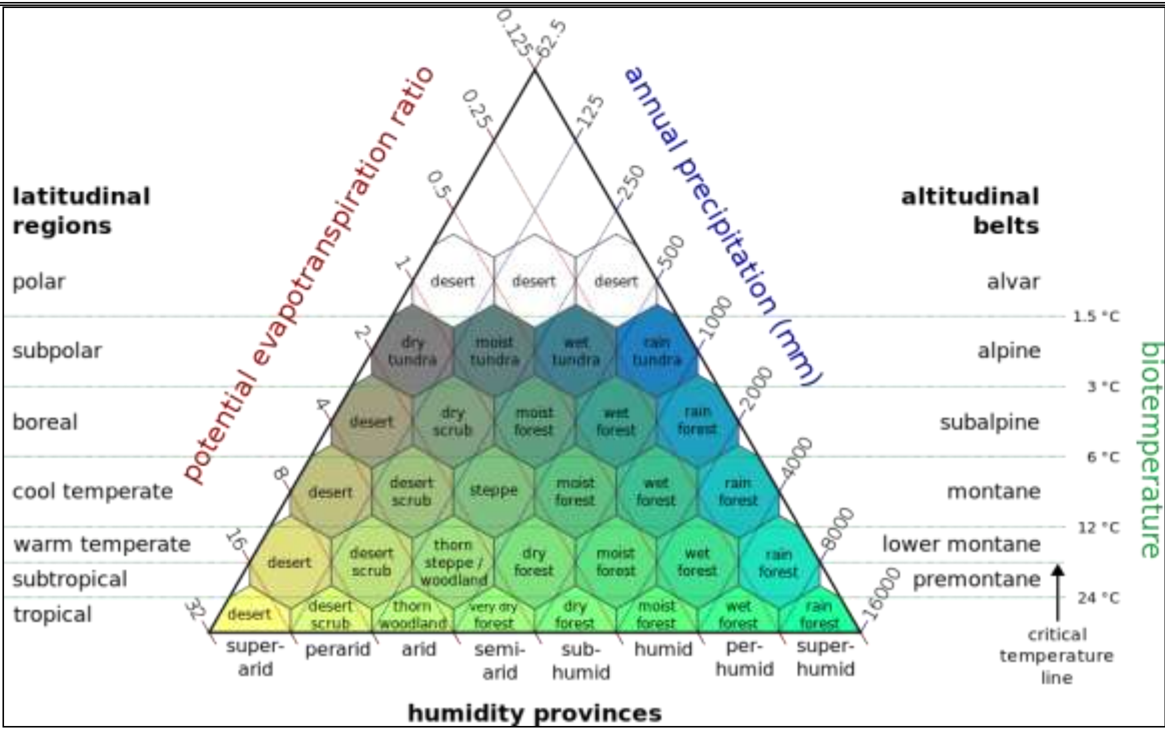


Figure 2.2.2.3.1. The climate classification system by Leslie Holdridge

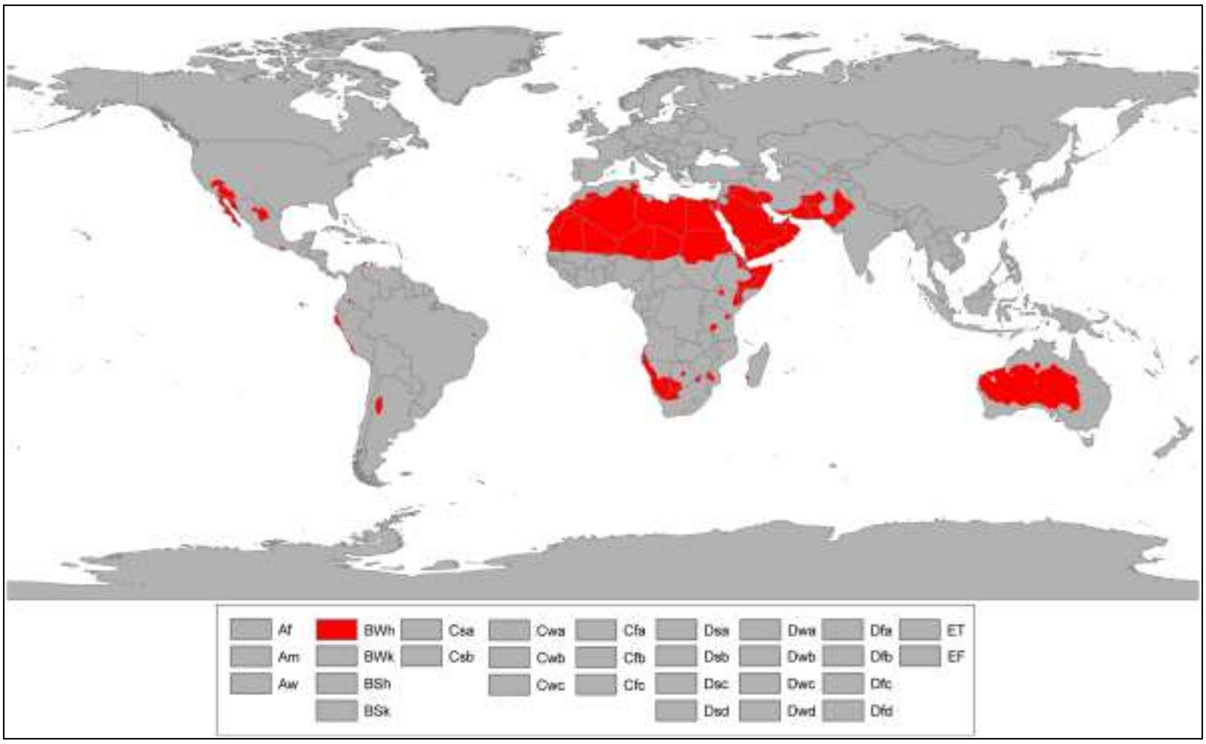


Figure 2.2.2.3.2. The Hot Deserts in the World

Hot desert climates are typically found under the subtropical ridge where there is largely unbroken sunshine for the whole year due to the stable descending air and high pressure aloft. These areas are located between 30 degrees south and 30 degrees north latitude, under the subtropical latitudes called the horse latitudes. Hot desert climates are generally hot, sunny and dry year-round.

Hot desert climates feature hot, typically exceptionally hot, periods of the year. In many locations featuring a hot desert climate, maximum temperatures of over 40 °C (104 °F) aren't uncommon in summer and can even soar to over 45 °C (113 °F) in the hottest regions. During colder periods of the year, night-time temperatures can drop to freezing or below due to the exceptional radiation loss under the clear skies. However, very rarely do temperatures drop far below freezing. In fact, the world absolute heat records are generally in the hot deserts where the heat potential is the highest on the planet.

The world's greatest hot desert regions include deserts of North Africa such as the wide Sahara Desert, the Libyan Desert or the Nubian Desert; deserts of the Horn of Africa such as the Danakil Desert or the Grand Bara Desert; deserts of Southern Africa such as the Namib Desert or the Kalahari Desert; deserts of the Middle East such as the Arabian Desert, the Syrian Desert or the Lut Desert; deserts of South Asia such as the Thar Desert; deserts of the United States and Mexico such as the Mojave Desert, the Sonoran Desert or the Chihuahuan Desert; deserts of Australia such as the Simpson Desert or the Great Victoria Desert and many other regions. Only one region in Europe has a hot desert climate, coastal areas of Almeria in South Eastern Spain. In fact, hot deserts are lands of extremes: most of them are the hottest, the driest and the sunniest places on Earth because of nearly constant high pressure; the nearly permanent removal of low pressure systems, dynamic fronts and atmospheric disturbances; sinking air motion; dry atmosphere near the surface and aloft; the exacerbated exposure to the sun where solar angles are always high.

2.2.2.4. Hidrology and underground water

Unlike other Gulf emirates, in Bahrain there are ancient springs of fresh water, but nowadays even here more than half of the fresh water consumed is obtained by seawater desalination.
The underground water table is about 3-18 m bellow the surface depending on the distance from the sea shore and the morphology – mainly the heights of the sediment materials. In the design and constructing these information must be taken into consideration.

2.3. Winner of the BID

The applicant and its partners have been agreed in establishing project company in Bahrain, to supervise the entire TCG project, and coordinating the activity of the third parties and subcontractors.

2.3.1. Name and address of the project company

The name of the project company will be SYNERGY & ITH JV.

All other specific data will be determined by the owners in a later stage

2.3.2. Executive/representative of the project company

To be determined in a later stage during the performance period of the Feasibility Study.

2.3.3. Contact information of the project company

To be determined in a later stage during the performance period of the Feasibility Study.

2.4. Governmental supporting documents

The Tender document contains all the official sapport provided by the Government, through the Ministry or other governmental offices or organizations.

2.5. Site requirements/Information

The required size of the project's site and the relative location of the units depend upon numerous parameters including but not limited to the capacity of the plant, geography of the available site, the location and availability of utilities, the location of the "connecting points" of the products to the market, the quality and quantity of the feed/input material(s) and availability and location of the waste material disposing systems, among many others.

Consequently, it is of the utmost importance that the detailed and complete site-specific data (including city or community requirements and ordinances) in order to develop a conceptual plan that offers the optimal design in terms of function and operations costs under the site-specific advantages and constraints are provided by the Government or its representative department.

The site, - determined in the Tender documentation – consists of two parts. As it can be seen in the Figure 3.3.1., the Northern part is 230 000 sq.m., and the Southern one is 330 000 sq.m.

The areas are provided by the Government and can be used for the entire period of the project.

2.5.1 Layout/plot specification

To be determined in a later stage during the performance period of the Feasibility Study.

2.5.2 Copy of the ownership title

To be determined in a later stage during the performance period of the Feasibility Study.

2.5.3 Location / the landfill site

To be determined in a later stage during the performance period of the Feasibility Study.

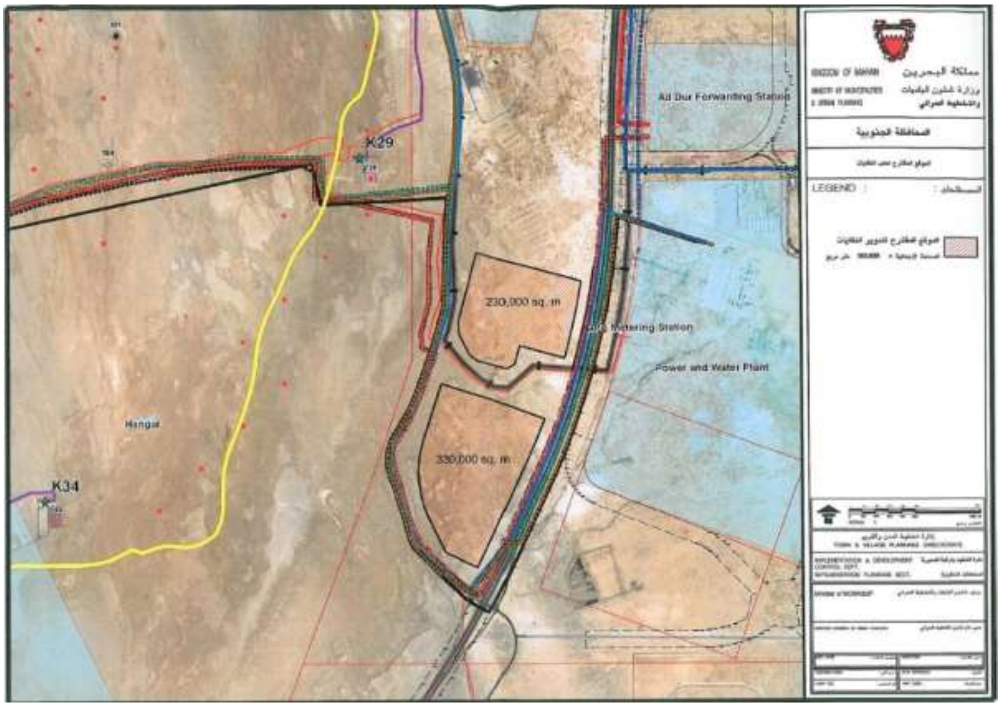


Fig. 2.5.3.1. The two parts of the site specified in the Tender documentation

Fig. 2.5.3.2. The site of the TCG-UC EL1500TH-TPY project

Due to the flexibility of the TCG-UC system, the feed/input material handling and processing system (called the AUXS/Pre-Selection Plant) and the different units of the power plant (TCG, GTE, etc.) can be located away from each other without any major disadvantages or significant cost effects, according to the local conditions. In the case that the waste material site fulfills a centralizing function (smaller sites transport the material to this site) and it is large enough to accommodate the feed/input material processing and handling system that may consists the pre-sorting, shredding and safety storage facility, the AUXS system should be located in that site away from the TCG and other units.

<u>This alternative provides notable advantages</u>:

1. only the fully utilized feed material need be transported to the TCG site,
2. the waste material from the pre-sorting process can be easily disposed on site,
3. the TCG unit can be sited close to or even within city or community limits (no smell, or dust or harmful material emission) close to the end product users, and
4. smaller site size requirements for the TCG plant unit, just to mention a few.
   (**Ref. Tender documentation Section 3**)

Consequently, the TCG and methanation and other final product manufacturing unit(s) can be located close to the product marketing/discharge points such as the local or national electric grid, city limits if utilizing the heat energy for district heating or in industrial processes.

The possible disadvantage of this alternative is that the feed/input material may have to be transported through city or municipal roads or highways which can significantly increase traffic congestion and result in somewhat increased environmental and safety concerns.

In present situation all the units of the TCG-UC Plant will be installed and operated on the landfill site where the feedstock has been being transported to, so the above mentioned traffic and transportation safety concerns have not been playing any roles in the TCG-UC EL1500TH-TPY project.

Because of the Site is far from populated-area so the transportation can be designed easily putting the weight point onto the logistics and the technical parameters of the system elements.

In this case - and that is why – two continuous transportation system, two conveyor belts were designed between the North- and South parts of the landfill site. One conveyor belt has been transporting the organic waste materials from the pre-selection plant to the TCG Plant, to gasify them, and an other conveyor belt system has been transporting the ash from the TCG Plant to the landfill storage areas (casettes).

This conveyor belt can also be used to transport the inorganic grained materials to the manufacturing plants – glass bubbla plant or silica plant – or to the landfill storage areas.

2.6. Basic data of the waste received

The input/feed material of the TCG-UC Power Plant (TCG-UC PP) system will be all organic (carbonaceous) material like the municipal solid waste, gardening/yard wastes and other biomass collected in Bahrain, the hazardous wastes like the medical wastes, and the organic and inorganic construction materials transported to the lendfill site.

FACTS: YEARLY 'TONNAGE ALL' REPORT FROM 2008 TO 2013

RAW DATA	D	B	A	A	C	X	
YEAR	DEAD ANIMAL	BUILDING WASTE	COMMERCIAL WASTE	DOMESTIC WASTE	GARDEN WASTE	INDUSTRIAL WASTE	TOTAL
2008	15 329,30	617 951,20	445 508,20	380 871,20	120 189,10	65 656,00	1 645 505,00
2009	16 570,50	570 455,80	320 432,40	402 241,20	149 153,10	73 672,60	1 532 525,60
2010	11 643,40	528 712,50	287 511,10	457 335,50	173 128,40	87 994,70	1 546 325,60
2011	9 785,30	534 473,50	247 013,10	430 836,10	117 613,10	83 566,90	1 423 288,00
2012	10 585,02	476 163,10	271 245,90	444 801,20	133 999,70	95 235,10	1 432 030,02
2013	9 063,90	518 919,40	268 594,30	463 859,70	151 094,70	84 016,80	**1 495 548,80**

Table 2.6.1. The yearly quantity of MSW between 2008 and 2013.

Estimated on 2013 as basis								
	D	**B**	**A**	**A**	**C**	**X**	**TOTAL**	
2014	9 517,10	544 865,37	282 024,02	487 052,69	158 649,44	88 217,64	1 570 326,24	TPY
2015	9 992,95	572 108,64	296 125,22	511 405,32	166 581,91	92 628,52	1 648 842,55	TPY
2016	10 492,60	600 714,07	310 931,48	536 975,59	174 911,00	97 259,95	1 731 284,68	TPY
2017	11 017,23	630 749,77	326 478,05	563 824,36	183 656,55	102 122,95	1 817 848,91	TPY
2018	11 568,09	662 287,26	342 801,95	592 015,58	192 839,38	107 229,09	1 908 741,36	TPY
2019	12 146,49	695 401,63	359 942,05	621 616,36	202 481,35	112 590,55	2 004 178,43	TPY
2020	12 753,82	730 171,71	377 939,15	652 697,18	212 605,42	118 220,07	2 104 387,35	TPY
2021	13 391,51	766 680,29	396 836,11	685 332,04	223 235,69	124 131,08	2 209 606,72	TPY
2022	14 061,08	805 014,31	416 677,92	719 598,64	234 397,47	130 337,63	2 320 087,05	TPY
2023	14 764,14	845 265,02	437 511,81	755 578,57	246 117,34	136 854,51	2 436 091,40	TPY
2024	15 502,34	887 528,27	459 387,40	793 357,50	258 423,21	143 697,24	2 557 895,97	TPY
2025	16 277,46	931 904,69	482 356,77	833 025,38	271 344,37	150 882,10	2 685 790,77	TPY
2026	17 091,34	978 499,92	506 474,61	874 676,65	284 911,59	158 426,21	2 820 080,31	TPY
2027	17 945,90	1 027 424,92	531 798,34	918 410,48	299 157,17	166 347,52	2 961 084,33	TPY
2028	18 843,20	1 078 796,16	558 388,26	964 331,00	314 115,03	174 664,89	3 109 138,54	TPY
2029	19 785,36	1 132 735,97	586 307,67	1 012 547,55	329 820,78	183 398,14	3 264 595,47	TPY
2030	20 774,62	1 189 372,77	615 623,06	1 063 174,93	346 311,82	192 568,04	**3 427 825,24**	**TPY**

Table 2.6.2. The estimated quantity of MSW between 2014 and 2030 in Bahrain

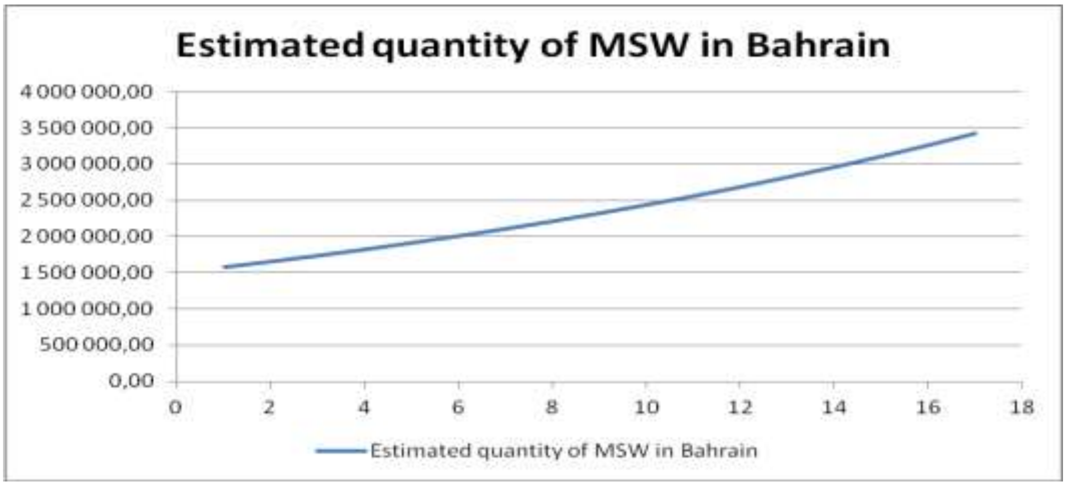


Figure 2.6.1. Estimated quantity of MSW in Bahrain
(Yearly growth=5%) (1=2014, 2=2015, …17=2030)

Considering both the fact and estimated quantities of the MSW generated in Bahrain and the capacity of the designed each TCG unit the number of the TCG and GTE Units can be calculated. The total feedstock requirement will be 514 tons per day (TPD) of each unit as received and pre-sorted basis.

					Capacity/TCG Unit		Number of
Year	**Quantity/Year**		**Inorganic**	**Organic**	**Daily (TPD)**	**Yearly (TPY)**	**TCG Units**
2014	1 570 326,24	TPY	39,28%	60,72%	514	160 411	**5,94**
2015	1 648 842,55	TPY	39,28%	60,72%	514	160 411	**6,24**
2016	1 731 284,68	TPY	39,28%	60,72%	514	160 411	**6,55**
2017	1 817 848,91	TPY	39,28%	60,72%	514	160 411	**6,88**
2018	1 908 741,36	TPY	39,28%	60,72%	514	160 411	**7,23**
2019	2 004 178,43	TPY	39,28%	60,72%	514	160 411	**7,59**
2020	2 104 387,35	TPY	39,28%	60,72%	514	160 411	**7,97**
2021	2 209 606,72	TPY	39,28%	60,72%	514	160 411	**8,36**
2022	2 320 087,05	TPY	39,28%	60,72%	514	160 411	**8,78**
2023	2 436 091,40	TPY	39,28%	60,72%	514	160 411	**9,22**
2024	2 557 895,97	TPY	39,28%	60,72%	514	160 411	**9,68**
2025	2 685 790,77	TPY	39,28%	60,72%	514	160 411	**10,17**
2026	2 820 080,31	TPY	39,28%	60,72%	514	160 411	**10,67**
2027	2 961 084,33	TPY	39,28%	60,72%	514	160 411	**11,21**
2028	3 109 138,54	TPY	39,28%	60,72%	514	160 411	**11,77**
2029	3 264 595,47	TPY	39,28%	60,72%	514	160 411	**12,36**
2030	3 427 825,24	TPY	39,28%	60,72%	514	160 411	**12,98**

Table 2.6.3. The calculation of the quantity of the TCG-UC Units

As it can be seen in the Table 2.2.3. there is needed minimum of 6 TCG-UC Units (+ 1 „hot" standby unit) in the first stage of the project, and about 13 TCG-UC Units in 2030 regarding the yearly growth of the quantity of MSW.

The detailed information on the MSW were provided in the tender documentation.

Sources of materials and tonnages **(see the "Tender documentation"Section 5.2.)**

The plant should be designed to accept material from the following sources

Source	**Approx. Tonnage per annum**
Domestic waste from Municipality vehicles	430,000
Commercial waste from private contractors	285,000

Table 2.6.4. The material sources (see the "Tender documentation"Section 5.2.)

Materials to be recovered / tonnages

The facility should be designed to allow recovery of the following materials:

Material	Requirements	Fate
Glass		aggregate (milling)
Steel cans	baled	Off-site reprocessing
Aluminium Cans	baled	Off-site reprocessing
Dense Plastics	Mixed, baled	Off-site reprocessing
Plastic film	Mixed, baled	Off-site reprocessing
Fibre	Sieved to 40mm	Thermal treatment
Residual waste	> 40mm	Landfill

Table 2.6.5. Materials to be recovered (see the "Tender documentation"Section 5.2.)

Materials to be recovered / tonnages

The facility should be designed to allow recovery of the following materials:

Material	Requirements	Fate
Sand	Sieved	Off-site reprocessing
Stone	Crushed, sieved	Off-site reprocessing
Concrete	Crushed, sieved	Off-site reprocessing
Paper	Transport	On-site re-processing
Plastics	Transport	On-site re-processing
Wood	Transport	On-site re-processing
Metals	Transport	On-site re-processing

Other waste	Transport	On-site re-processing

Table 2.6.6. Materials to be recovered / tonnages (see the "Tender documentation"Section 5.3.)

Sources of Constructing waste materials and tonnages

(see the "Tender documentation"Section 5.3.)

The plant should be designed to accept material from the following sources

Source	Approx Tonnages per annum
Mixed construction waste from the private sector and from the Municipality contractors	525,000*

Table 2.6.7. Approximate tonnages of Mixed construction waste per annum
(see the "Tender documentation"Section 5.3.)

The Thermal treatment facility (see the "Tender documentation"Section 5.5.)

The plant should be designed to accept material from the following sources

Source	Approx Tonnages per annum*
Animal carcasses	20,000
Reception Facility rejects	40,000
C/D recycling rejects	45,000

Table 2.6.8. Materials to be recovered / tonnages
(see the "Tender documentation"Section 5.3.)

The TCG-UC EL1500TH-TPY Waste to Green Energy Production System based on „Thermo-Chemical Gasification Technology", is the most environmentally-friendly energy generation process to utilize organic, municipal solid waste, and any carbonaceous materials or their mix in any proportion as feedstock with near-zero emissions.

(Ref: Tender documentation Section 5.4.)

2.7. The required final products

The final products were specified as of electricity and thermal energy.

2.7.1. The syngas (synthesys gas)

The transitional product is the synthesys gas, produced by the TCG units, thermo-degradating the solid organis waste materials into mixture of the following four gases. CO, CO_2, CH_4, and H_2. The ratio of these gases can be determined by the operator of the TCG Unit, considering the market and the other issues and requirements.

Syngas is combustible and often used as a fuel of internal combustion engines. It has less than half the energy density of natural gas.
Production methods include steam reforming of natural gas or liquid hydrocarbons to produce hydrogen, the gasification of coal, biomass, and in some types of waste-to-energy gasification facilities.

Syngas is also used as an intermediate in producing synthetic petroleum for use as a fuel or lubricant via the Fischer–Tropsch process and previously the Mobil methanol to gasoline process

The main reaction that produces syngas, steam reforming, is an endothermic reaction with 206 kJ/mol methane needed for conversion.

The first reaction, between incandescent coke and steam, is strongly endothermic, producing carbon monoxide (CO), and hydrogen H_2 (water gas in older terminology).

When the coke bed has cooled to a temperature at which the endothermic reaction can no longer proceed, the steam is then replaced by a blast of air.

The second and third reactions then take place, producing an exothermic reaction - forming initially carbon dioxide - raising the temperature of the coke bed - followed by the second endothermic reaction, in which the latter is converted to carbon monoxide, CO. The overall reaction is exothermic, forming "producer gas" (older terminology). Steam can then be re-injected, then air etc., to give an endless series of cycles until the coke is finally consumed. Producer gas has a much lower energy value, relative to water gas, due primarily to dilution with atmospheric nitrogen. Pure oxygen can be substituted for air to avoid the dilution effect, producing gas of much higher calorific value.

When used as an intermediate in the large-scale, industrial synthesis of hydrogen (principally used in the production of ammonia), it is also produced from natural gas (via the steam reforming reaction) as follows:

$$CH_4 + H_2O \rightarrow CO + 3\ H_2$$

In order to produce more hydrogen from this mixture, more steam is added and the water gas shift reaction is carried out:

$$CO + H_2O \rightarrow CO_2 + H_2$$

The hydrogen must be separated from the CO_2 to be able to use it. This is primarily done by pressure swing adsorption (PSA), amine scrubbing, and membrane reactors.

In our TCG Plant, the gas and water cleaning system is a complex patented technology that is able to produce potable water from sewage water in one step. Due to this extraordinary gas cleaning technology the gas turbines of the GTE Units produce only about 60% of the emission of an ordinary gas turbine – with same capacity – operated with Natural gas.

2.7.2. Electricity

Depending upon the quantity and quality of the syngas the electricity genarator unit – GTE- Gas To Electricity – consists of different capacity Gas Turbine or Gas Motors with the Generator set. In case of a 10-12 MW estimated electricity production or above, the Gas Turbine is the better equipment.

Varying compositions, as well as calorific values and the combustion behaviour of the gases from synthetic gases processes, put greater demands on engine design. There are for example specially modified GE Jenbacher gas engines that make efficient use of these gases for combined generation of heat and electricity. Special features of these engines may include flame arrestors for the prevention of backfiring, special gas mixers to improve gas mixing and to be more robust to dirt. In general, the stable composition of wood gas makes it advantageous as an engine fuel. The high hydrogen content of some syngases however, means the combustion process is very fast, which increases the danger of engine pre-ignition, knocking or engine backfiring. To avoid this risk, there has been developed and created an engine control system that is able to fuel the GE Jenbacher engine with a very lean mixture and, at the same time, react very quickly to variations in the engine load.

Some synthetic gases have a high carbon monoxide content, which has a low combustion speed and is very harmful. There are also developed the specific gas engine combustion system that enables burning of the gas efficiently and reliably. These developed engines offer a safety technology package solution that allows firm handling of harmful gases such as carbon monoxide.

The TCG-UC Green Energy Power Plant systems are able to prevent all the dangerous situations, due to the continuously operated data collecting-analysing-and storing system that controls the processes and models the steps to be done by the operator of the TCG units. A complex gas analisys system is operated during the entire production period (7/7 and 24/24).

Sample GTE modeling.

Customer: STS Group		Model: TAURUS 60-7901
		Package Type: GSC
Job ID		Match: STANDARD
Run By: Christopher S Burns	Date Run: 24-May-10	Fuel System: GAS
Engine Performance Code: REV. 3.42	Engine Performance Data: REV. 2.0	Fuel Type: CHOICE GAS

DATA FOR NOMINAL PERFORMANCE

Elevation	metres	120
Inlet Loss	mm H2O	100.0
Exhaust Loss	mm H2O	250.0

		1	2	3	4	5	6
Engine Inlet Temperature	deg C	-20.0	0	10.0	15.0	30.0	40.0
Relative Humidity	%	60.0	60.0	60.0	60.0	60.0	60.0
Specified Load*	kW	FULL	FULL	FULL	FULL	FULL	FULL
Net Output Power*	kW	6836	6184	5850	5685	5062	4641
Fuel Flow	kcal/sec IT	5011.46	4621.43	4427.77	4332.56	4012.08	3814.01
Heat Rate*	kJ/kW-hr	11048	11262	11406	11485	11944	12386
Therm Eff*	%	32.581	31.960	31.557	31.341	30.136	29.061
Engine Exhaust Flow	kg/hr	85698	81652	79349	78050	73129	69682
Exhaust Temperature	deg C	498	507	511	514	527	537

Fuel Gas Composition (Volume Percent)		
	Methane (CH4)	10.10
	Carbon Monoxide (CO)	15.30
	Carbon Dioxide (CO2)	11.40
	Hydrogen (H2)	63.20
	Sulfur Dioxide (SO2)	0.0001

Fuel Gas Properties						
	LHV (kcal/Nm3)	2951.1	Specific Gravity	0.4211	Wobbe Index at 60F	483.9

**Electric power measured at the generator terminals.*

This performance was calculated with a basic inlet and exhaust system. Special equipment such as low noise silencers, special filters, heat recovery systems or cooling devices will affect engine performance. Performance shown is "Expected" performance at the pressure drops stated, not guaranteed.

Figure 2.7.2.1

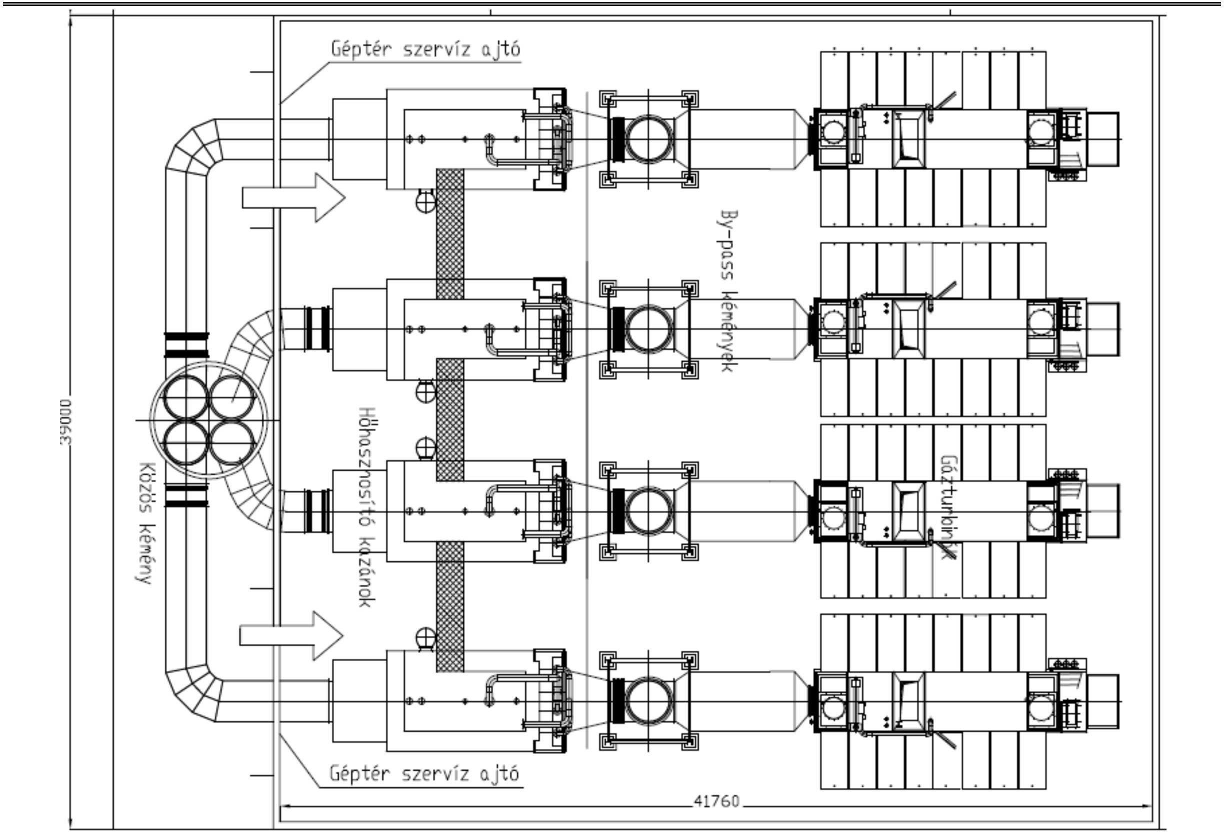


Figure 2.7.2.2. Gas turbine and heat recovery system

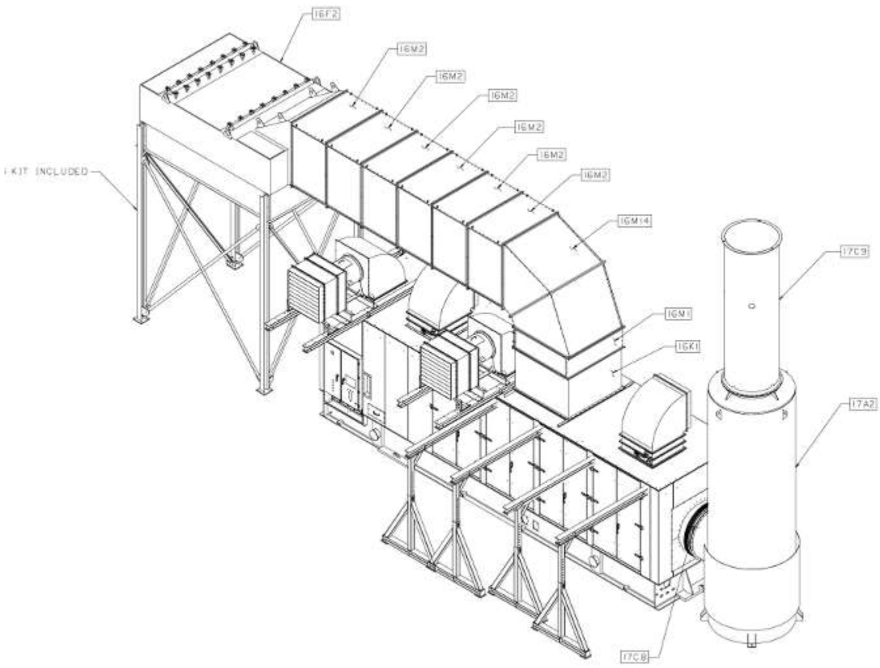


Figure 2.7.2.3. One gas turbine unit

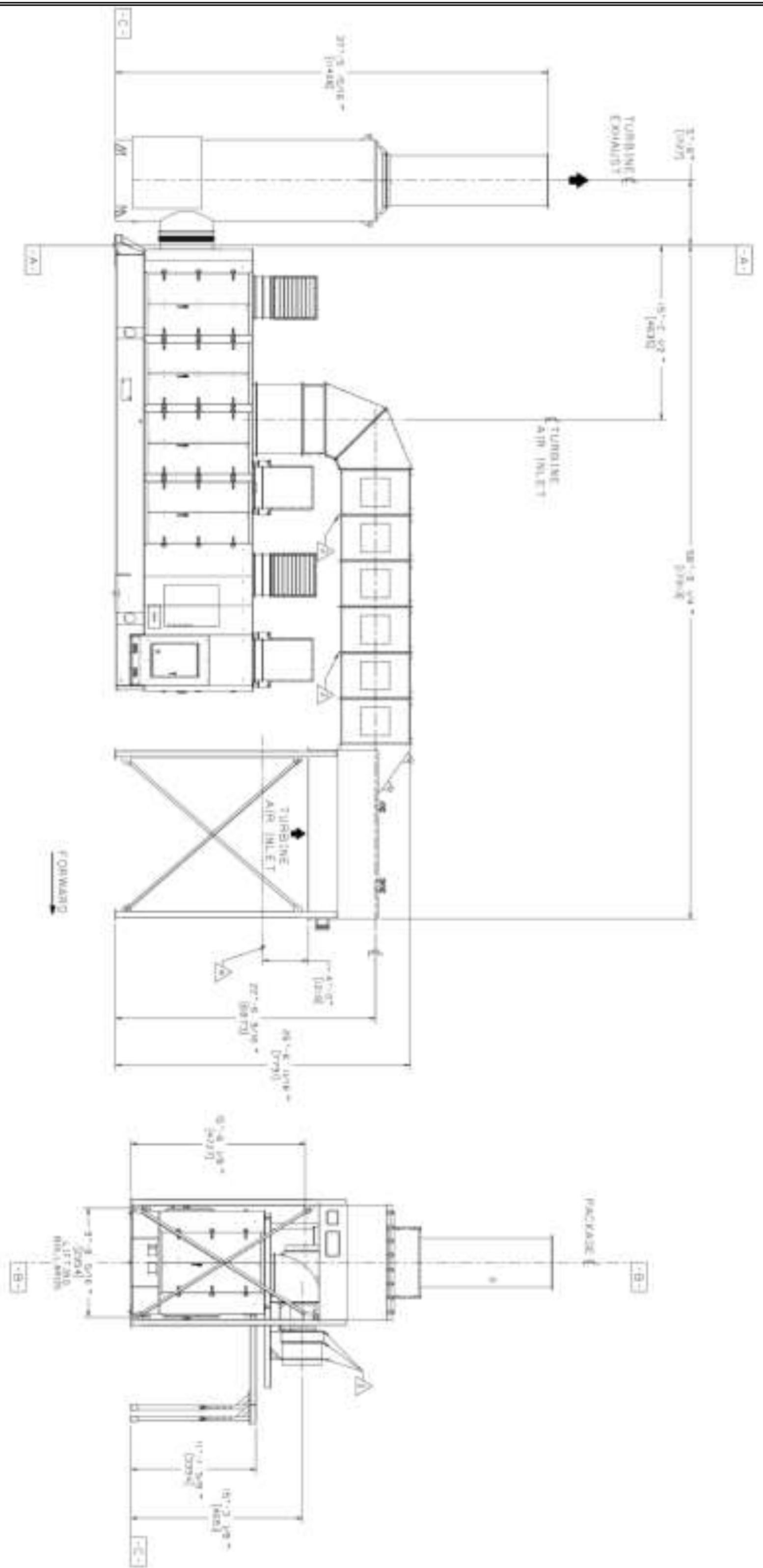


Figure 2.7.2.4. Front view of the GTE Unit

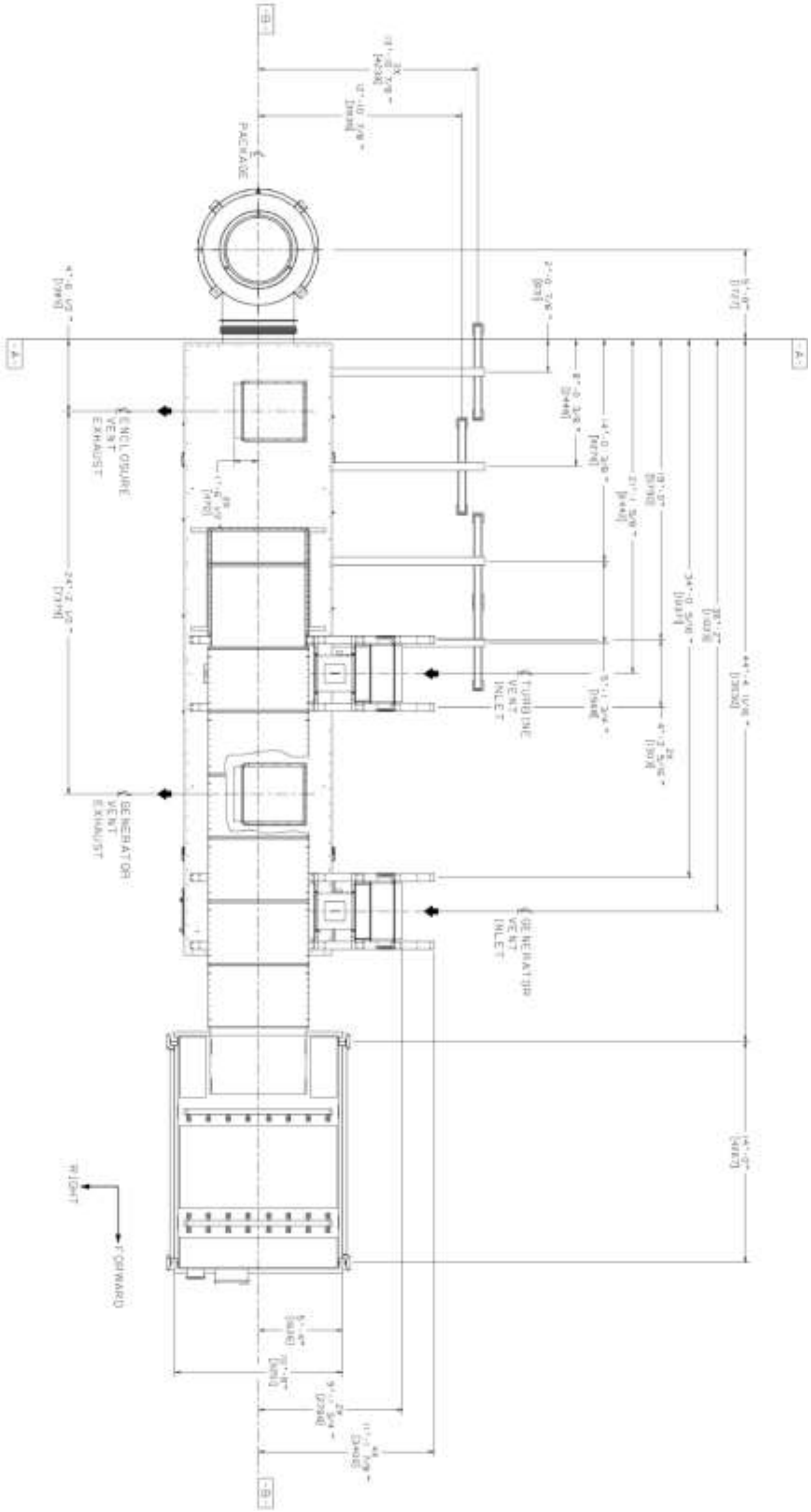


Figure 2.7.2.5. Plan view of the GTE Unit

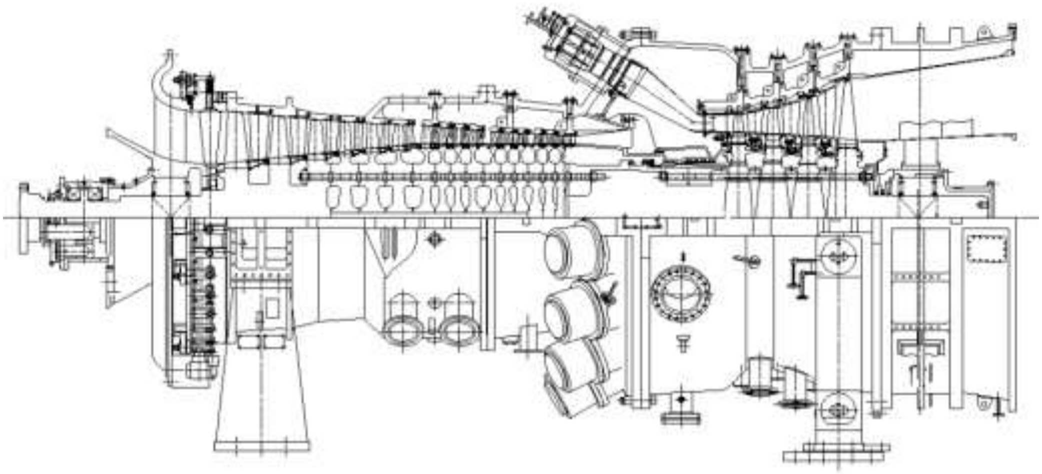


Figure 2.7.2.6. Longitudinal section of Gas Turbine

2.7.2.1. The connection/discharging points for the end products

In electrical grids, a power system network integrates transmission grids, distribution grids, distributed generators and loads that have connection points called busses. Traditionally, these grid connections are unidirectional point to multipoint links. In distributed generation grids, these connections are bidirectional, and the reverse flow can raise safety and reliability concerns. Features in smart grids are designed to manage these conditions.

A power station is generally said to have achieved *grid connection* when it first supplies power outside of its own boundaries. However, a town is only said to have achieved *grid connection* when it is connected to several redundant sources, generally involving long-distance transmission.

The TGC-UC Power plant can provide connection points for both the national electricity grid and the steam pipeline network (if it is needed).

The electrical substation is designed together with other units and elements of the TCG-UC Power Plant, and installed and operated inside the site of the plant.

Figure 2.7.2.1.1. Small electrical substation

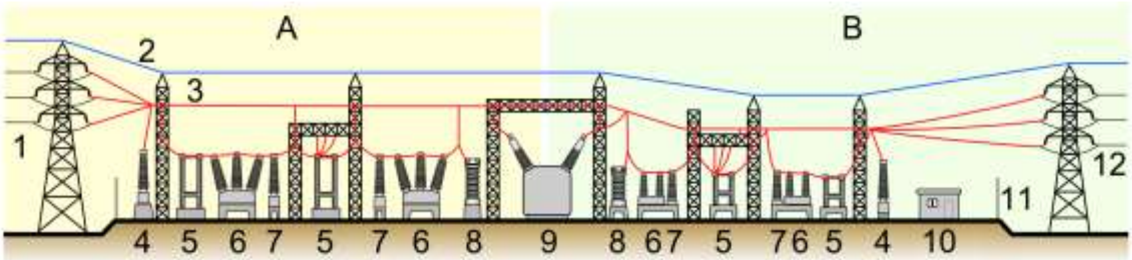


Figure 2.7.2.1.2. The electrical substation

2.7.2.2. AlDur Power and Water Company

Al Dur Power and water company has been established to provide clean, reliable and competitive priced sources of power and water for Bahrain. This industrial center is about 2 Km to East-North-East from the northern part of the landfill site, and provides a high quality and safe partner in distributing the green electric energy produced in TCG-UC PP.

The plant consists of a Combined Cycle Gas Turbine power plant and a Reverse Osmosis (RO) technology desalination plant together with all support facilities such as seawater intake and discharge structures and gas connection facilities. The IWPP will have a capacity of 1,234 MW of power and 218,200 cubic metres per day.

2.7.2.3. The maximum uplodable energy to the grid

To be determined in a later stage during the performance period of the Feasibility Study.

2.7.3. Thermal energy

The thermal energy generated in the TCG and GTE Units, can be used in central heating/cooling system or in different industrial activity. Depending the environmental and weather conditions and circumstances several activity, manufacturing and service can be supported and secured by this thermal energy.

2.7.3.1. Map of the connecting point

To be determined in a later stage during the performance period of the Feasibility Study.

2.7.3.2. Capacity

Each TCG Unit generates about 15.3 MWth thermal energy (56.4 GJ/h). The GTE Units are also producing heat energy, that can be collected and applied in industrial manufacturing activity. The available thermal energy can be calculated from the specific data of the TCG and the GTE units.

Several plans are worked out by the owner of the TCG technology to utilize the thermal energy, instead of its dissipation.

2.7.4. Possible alternative utilization of thermal energy

Some of the well known applications are listed bellow.

Central heatin/Cooling systems, (Absorption refrigerator)

An **absorption refrigerator** is a refrigerator that uses a heat source (e.g., solar energy, a fossil-fueled flame, waste heat from factories, or district heating systems) which provides the energy needed to drive the cooling process.

Absorption refrigerators are often used for food storage in recreational vehicles. The principle can also be used to air-condition buildings using the waste heat from a gas turbine or water heater. This use is very efficient, since the gas turbine then produces electricity, hot water, and air-conditioning (called cogeneration/trigeneration).

Agriculture

Special crop production systems
Pet breeding systems (rabbits, chickens, lamb,)
Fishery,

Industrial applications

Figure 2.7.4.1. Modern automatized greenhouse systems

Figure 2.7.4.2. Harvesting in the greenhouse

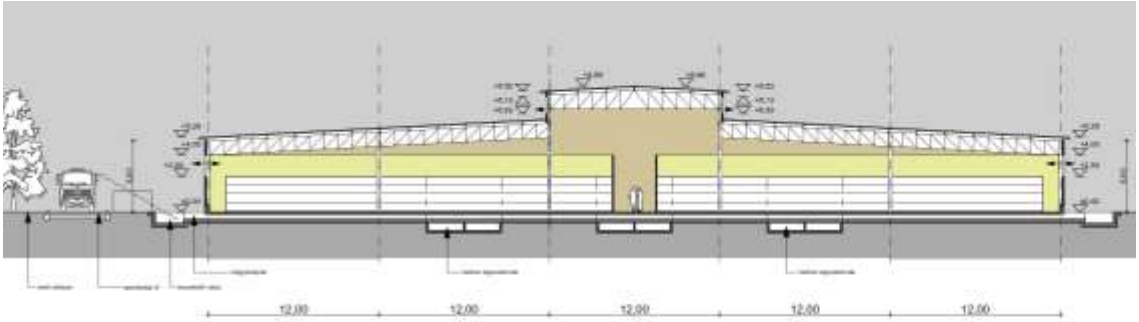


Figure 2.7.4.3. Rabbit breeding center I

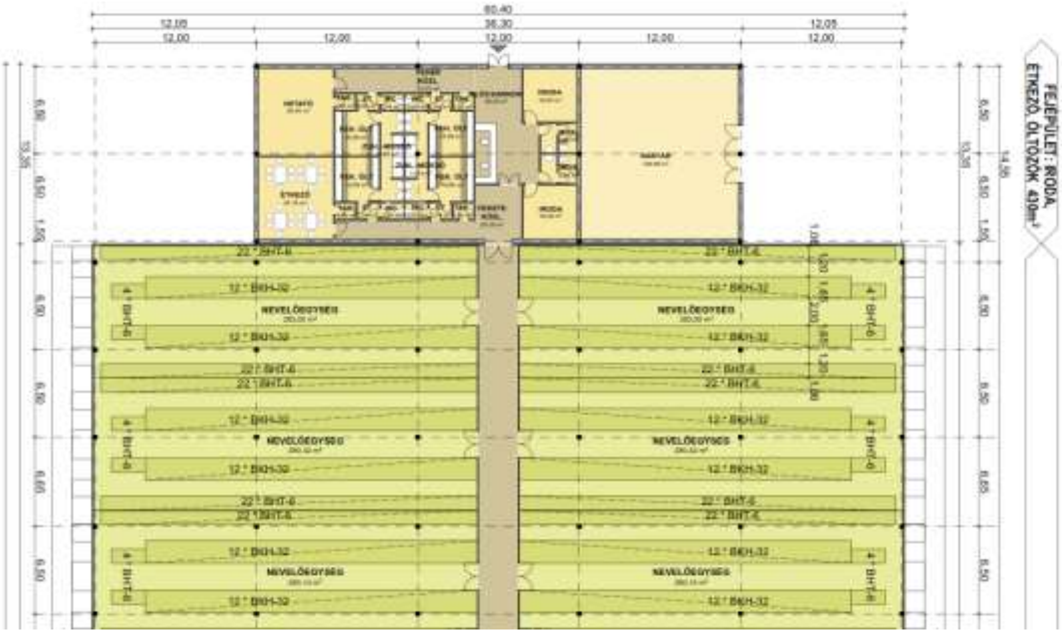


Figure 2.7.4.4. Rabbit breeding center II

Figure 2.7.4.5. Pet breeding system

Industry,

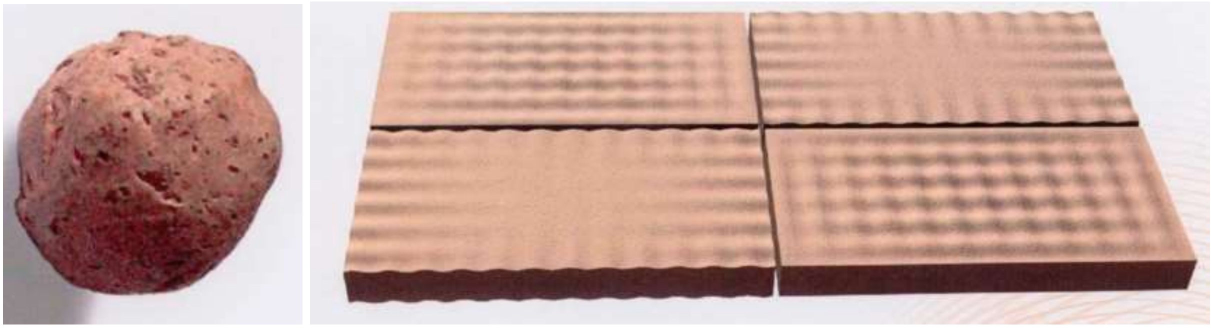


Figure 2.7.4.6. Thermal isolation materials and constructing elements

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III. THE TECHNOLOGY

3. Technology

In human history, we can distinguish various ages such as the Copper, Bronze, or Iron Age. In a similar fashion, our present time could be called the "Plastic Waste Age" due to the immensity of plastic waste gathering around the world and in the oceans.
The awesome quantity of plastic waste, exacerbated by animal and human waste containing pathogens that are immune to many present day pharmaceutical products, present an insurmountable problem in terms of environmental and health hazards that cannot be remedied with environmentally-friendly solutions. The "mega-cities" are suffocating under the solid waste handling and disposal problems that are aggravated further with the quantity and quality of the organic sludge from the waste water treatment plants. The presently applied solutions cost the cities and communities many millions of dollars, aggravating the already dire fiscal and economic situations around the globe.

The Earth is a living inorganic and organic ecosystem that contains a tremendous force to keep the equilibrium or re-establish the equilibrium if any natural or man-made catastrophe or significant intervention disturbs that equilibrium. Nations are ready to accept higher prices of producing and maintaining the energy supplies, agricultural and biological needs of their contemporary societies in order to assure similarly livable conditions for their children and the subsequent generations. Such forward-thinking societies continuously invest huge financial resources to develop new environmentally friendly technologies that create the least hostile interference with the environment.

TCG, Thermo-Chemical Gasification is technology that provides the best environmentally friendly solutions, providing not only technological advantages but economic ones as well, because it utilizes waste material that is a renewable resource and at the same time provides a solution to the both huge waste management, handling and disposal problems for all cities and communities.

TCG technology is not merely one solution among the many, but it is that special solution that provides the best presently available answer to the problems associated with the environmental contamination problems that the presently huge levels of urban waste—the millions of used tires, the almost unmanageable organic industry waste handling and remediation—creates for society. TCG plants emit no harmful or toxic contaminants, the processing units have no chimneys, therefore during the conversion of the carbonaceous materials into energy, the system has no material emissions into the environment.

TCG technology is capable of converting any carbonaceous (organic) materials (such as organic sludge; municipal solid waste; biomass; energetic woods or grass; used tires; distillate, oil refinery, or paper-industry residues; or any mix of these materials) into a synthetic gas whose composition is well-controlled without the uncontrolled emission of gas or liquid materials into the environment. The produced synthetic gas (SynGas) can be used directly in gas motor/generator sets to generate electricity or serve as the feedstock for producing methanol, ethanol, diesel, Jet Fuel, synthetic natural gas etc. The TCG plant can be used for hydrogen production as well.

3.1. Expected advantages of the plant, technical parameters and accessories

- Multi-feedstock capable
  - Coal, petcoke, biomass and refuse-derived fuel, etc.
- Syngas quality projected at 200-600 Btu/SCF
  - Vs. Large or Comparable Competition's 200-350 Btu/SCF
  - Technology ranked No. 1 by group of leading US Agency Scientists/Engineers
- Air and Water Emissions
  - Environmental Permitting – Comparable to Natural Gas
  - Fewer permits required for brown-field site expansions (Syngas to existing Boiler)
  - Air permits easier to obtain at green-field sites due to lower emission profile
- Emission compliant for SOx, NOx and Mercury
- High thermal conversion yields low CO_2
- Serves as substitute fuel gas
- Proprietary gas and water clean-up system
- Fischer-Tropsch catalyst ready
- Power Generation Scenario: (60 MW Wiley IGCC)
- Gasifier is a "green" technology
- Competitor technologies capital investment is 2-10 times more
- Power generation and distillate production identified as best development opportunities in terms of revenues and returns in comparison to fuel gas only
- Tax credits may apply with specific feedstocks, back-end module selections and geographic locations
- Cutting-edge technology:
  - Gasifier fuel flexibility provides multiple feedstock options
  - Product: Syngas – natural gas substitute, feed for electricity, distillate and/or hydrogen
  - Water clean-up technology is un-paralleled
  - Back-end module selections ultimately define products slate
- Syngas production is capable of firing gas turbines and/or reciprocal engines
- Lead time on plant delivery is 16 to 18 months
- Feedstock rates (nominal)
  - 250-500 TPD coal, petcoke, MSW
  - 500-1,000 TPD biomass (i.e. wood chips, crop residue)
- Modular design promotes assembly/disassembly
- Small footprint 500 tpd (100'X100'X25')
- Well designed
  - Construction quality, assembly/disassembly, ease of maintenance
- Scale-up or More Capacity Desired - Add plant modules
- Permanent U.S. and International patents pending

- A COMMERCIAL SCALE REFERENCE PLANT DEMONSTRATING THIS TECHNOLOGY IS OPERATING

3.2. Brief description of the applied technology for major units

3.3. History of the technology

<u>**Gasification technology**</u> has been in use for over 100 years from the "town gas" operations in the late 19th and early 20th centuries. The arrival of electricity displaced these first commercial gasification plants and the technology laid dormant until German scientists employed gasification to produce oil during WWII. In the early 1950s, gasification was revived for use in refineries to dispose of low value refinery byproducts for the production of hydrogen. It was also used in areas of the world to produce various chemical feed stocks. In the early 1970s, research was initiated on using solid fuel as the primary feedstock in the gasification process. By the late 1980s, gasification technology was then integrated with a combined cycle power plant to produce a high efficiency low-emission coal fueled power plant.

As natural gas prices were rising in the <u>**1970s**</u>, Shell, Texaco, and Dow Chemical each initiated research projects to develop solid fuel gasification technology to replace natural gas. These efforts culminated in building demonstration coal gasification projects **in the <u>early 1980</u>**<u>s</u>. Eastman Chemical Company built the first commercial scale coal gasification plant in 1984 at their Knoxville, Tennessee plant using syngas as a feedstock replacement for natural gas. This plant uses the Texaco gasification technology and has been in successful continuous operation for over 22 years.

<u>**In the early 1990**s</u>, government supported efforts were initiated in the United States and Europe to build commercial coal gasification IGCC projects. Dow technology was applied at the Wabash, Indiana plant and Texaco technology at the Tampa, Florida Plant. Shell technology was utilized at the Buggenum plant in Europe. These projects were demonstration plants used to advance the technology and establish coal gasification as a viable, clean electric power generating option. Each project successfully expanded the knowledge base, and demonstrated the potential of the technology, and provided invaluable lessons for the commercialization of solid fuel gasification. The Gasification technologies have been used in Europe and the United States for many decades. Many research organizations supported by the U.S. Department of Energy and other European government agencies have conducted extensive research and new development on gasification technologies, and companies like Sasol-Lurgi, GE/Texaco, Conoco/Phillips and Shell have emerged as major developers of commercial gasification plants.

The unique capability of the plant for utilizing a mixed fuel of coal and biomass in any proportion may provide synthesis gas composition from H2:CO=1:1 to H2:CO=1:3 which is most desirable for production of synthesis fuel, such as ethanol, mixed alcohols, diesel, gasoline, and jet-fuel. (Schuetzle, et al. 2007)

The US House of Representatives, Science and Technology Committee, Subcommittee on Energy and Environment had requested testimony on research and development issues for producing liquid fuels from coal on September 5, 2007. Nationally and internationally recognized environmental scientists and researchers such as Mr. Bartis from RAND Corporation and Dr. Boardman from Idaho National Laboratory testified on the importance of this very issue.

The committee unanimously recommended to the federal government for support research on coal gasification and associated synthesis gas cleaning and treatment processes. These programs are near-term, relatively low risk concepts related mostly for power generation and hydrogen production. That said, many of the programs are also applicable to Fischer-Tropsch (F-T) technology to liquid fuels.

Dr. Boardman states, "What is missing from the federal R & D portfolio is a near-term effort to establish the commercial viability of a new techniques for the combined area of coal and biomass. Such a combination offers significant cost and environmental payoffs. The most pressing near-term research need centers on developing an integrated gasification system capable of handling coal, biomass, and any other carbonaceous feedstock."

Mr. Michael A. Aimone, the Air Force's Assistant Deputy Chief of Staff for Logistics was recently quoted that by 2025 the Air Force wanted to meet 70% of its fuel needs with fuel produced from "coal-based sources". The plant is a perfect facility for synthetic gas production for jet fuel and readily lends itself to rapid deployment due to its modular design and low cost manufacturing techniques similar to those used in the auto industry.

Gasification and pyrolysis technology has long been known and utilized in both Europe and the United States. The U.S. Department of Energy (DOE) and other organizations set up by European governments have already undertaken and are currently engaged in extensive research to develop gasification technology, which along with current technology providers such as Sasol-Lurgi, GET/Texaco, Conoco/Philips, or Shell, could provide excellent opportunities for commercial endeavors in the field of synthetic energy production.

The **TCG System** is the result of a CONTRACTOR between existing and newly patent-protected processes. U.S. Patent Number 60/791, 401 followed several years of research and development, and ensures the protection of the equipment and the processes involved.

The recognized expert institutes (**RAND Corporation** and **The Idaho National Laboratory)** of the U.S. House of Representatives Science and Technology Committee (the **House of Science and Technology Committee)** and the Energy and Environment Subcommittee (**Subcommittee on Energy and Environment**) carried out a comparative study of the currently-available coal gasification technologies and plants.

The results of the three most promising processes were, in anonymity, selected based solely upon their technical characteristics by an independent committee, and placed before the Senate. The comparative study was the basis upon which the Committee suggested the introduction of the TCG technology in the broadest-possible areas and levels in the nation's energy structure, in addition to also suggesting financial support for carrying out further development and testing on the technology utilizing the operating TCG plant in Toledo, Ohio. The specific advantages of the TCG system that it is capable of producing Syngas with an H_2:CO=2:1 ratio, which is extremely advantageous in the case of developing hydrogen based energy systems or in the case of the application of methanisation processing.

This decision and certification will contribute significantly to the broader introduction and implementation of the TCG technology.

It has already been noted that the equipment and its testing has been supervised and certified by independent monitoring organizations. **TSS Consultants** thoroughly examined the TCG System and compared its parameters to those of the six best-known and regarded competitors (refer to earlier table and information).

The Parameters Examined Were:

- Efficiency
- Safety and Reliability
- Energy Efficiency
- Environmental Impact Indicators
- Economic Viability

Biomass to Energy Technologies [1]	(E1) Economic Analyses (Electricity Cost ($/KWH) & Amortized Cost) [2]	(E2) Energy Analyses (Electricity (KWH/yr & Heat (MT/yr))	(E3) Environmental Assessment	(E4) Evaluation (RDD&D [3] Validation)	(E5) Effectiveness	(E6) Total Rating
Thermal Pyrolysis/Steam Reforming (No Oxygen)	$0.048/KWH $4.07 M/yr *(17)*	$6.64 \times 10^{+7}$ KWH/yr & 1.0 MT/yr) *(9)*	*(8)*	*(8)*	*(8)*	*(50)*
Integrated Thermal Gasification/ Oxidation	$0.054/KWH $3.38 M/yr *(15)*	$3.76 \times 10^{+7}$ KWH/yr & 2.0 MT/yr *(7)*	*(7)*	*(13)*	*(7)*	*(49)*
Thermochemical Gasification (No Oxygen	$0.067/KWH $5.05 M/yr *(12)*	$6.20 \times 10^{+7}$ KWH/yr & 1.0 MT/yr *(8)*	*(8)*	*(6)*	*(8)*	*(42)*
Thermochemical Gasification (With Oxygen)	$0.079/KWH $5.17 M/yr *(8)*	$5.53 \times 10^{+7}$ KWH/yr & 0.90 MT/yr *(7)*	*(6)*	*(14)*	*(6)*	*(41)*
Thermal Pyrolysis (No Oxygen)	*Not Applicable*	*Not Applicable*	*(5)*	*(6)*	*(5)*	*Not Applicable*
Thermal Oxidation (Combustion)	$0.174/KWH $5.82 M/yr *(3)*	$2.57 \times 10^{+7}$ KWH/yr & 1.5 MT/yr *(5)*	*(2)*	*(18)*	*(2)*	*(30)*

- **1.** Numbers in Italics represent ratings for E1-E5 – See Section 3.2 for details on rating system criteria
- **2.** Total Costs = Straight-line deprecation of capital costs (20 years depreciation of capital expenditures) plus annual operating and maintenance costs. The electricity cost calculation assumes that the EBMUD facility will be able to utilize up to 2.0 million Therms of heat energy each year
- **3.** RDD&D: Research, Development, Demonstration and Deployment Assessment Stages.
- **Table 3.3.1. The result of the international analisys of alternative clean coal technologies**

The resultant analysis indicated that the "TCG – Thermo-Chemical Pyrolysis/Steam Reforming Process"—as undertaken in an air/oxygen-poor environment—**"produced operating results superior to currently implemented processes and technology."**

TSS Consultants concluded that the

„TC thermo-chemical pyrolysis/steam refining process when conducted in absence of oxygen or air is superior to all other existing technologies examined."

3.4. Theory of the technology

Gasification of biomass perhaps can appear deceptively simple in principle and many types of gasifiers have been developed. The production of combustible syn-gas from biomass input fuel may have attractive potential benefits perhaps such as ridding the environment of noxious waste disposal problems, possible ease of handling, and perhaps providing alternative energy production with possibly the release of low levels of atmospheric environmental contaminants. Further, cheap electricity generation and the application of the produced syn-gas as an economical energy source for the manufacture of liquid fuels may also often make gasification very appealing.

However, the biomass input feedstock which is used in gasifiers may challenge perceptions of uncomplicated design simplicity since the feedstock material may represent varying chemical characteristic and physical properties, perhaps as inherent and unique to each individual biomass feedstock material. The chemical reactions involved in gasification, relative to processing the different varieties of available biomass materials, may involve many different reactants and many possible reaction pathways. The reaction rates are often relatively high; all these variable factors may contribute to the perhaps very complex and complicating nature of gasification processes. All too often uncontrollable variables may exist that may make gasifiers hard to mass balance control and perhaps to operate satisfactorily within known preventive maintenance procedures, steady-state output constants, and manageable environmental control compliance areas.

Numerous U.S. patents have been issued relating to alternative or renewable energy technology descriptions involving gasification or syn-gas technologies. The present TCG technology perhaps may overcome many of the operational disadvantages associated with and perhaps commonplace to current and commercially viable processes involving existing gasification systems. The various types of available market updraft, downdraft, air-blown, fixed bed, fluidized bed, circulating fluidized bed, pulsed-bed, encapsulated entrained flow, and other gasification systems may often have one or more serious disadvantages that perhaps may be overcome by the present TCG technology.

In conventional gasification systems, disadvantages often may exist that may create problems in perhaps a variety of areas, including but not limited to areas such as: process control stability related to input feedstock changes, steady state loading, blockage and overall system throughput limitations; slagging potential and challenges; scale-up sizing challenges; moisture limitations; system gas and internal vapor leak challenges; carry-through impurities and contamination challenges, system plugging challenges (such as with excess char, tars or phenols); problems with generated hydrocarbon volatiles and other corrosive sulfur vapor carry-through contaminants being released into produced synthesis gas; decreased BTU energy values in final produced synthesis gas (such as due to excess CO_2, N_2, or particulate contamination); and the like.

It incorporates several new technological developments and design features such as:

- modular construction and shop fabrication;
- no requirement for refractory brick;

- no requirement for separation and injection of oxygen;
- no sensitivity to moisture content in the feedstock;
- no requirement for pulverization or slurry injection of feed;
- flexibility in feedstock alternatives including varying proportions of coal, pet coke, biomass, sewer sludge or other organic waste in different proportions;
- utilization of a unique ionized water treatment system;
- capability of recycling un-reacted carbons back into the reactor chamber, and a near-zero air emissions and liquid discharge.

In addition, some of the carbon dioxide generated in the gasification process can be captured and recycled as feedstock. Further the potential exists to readily integrate this system into a portable, flexible gas-to-liquids bio-refinery. There is substantial commercial potential in the TCG unit.

During the last years, many novel design aspects have been further developed that culminated in a US patent filed on April 11, 2006, application No: 60 / 791,401.

The „TCG-UC System" covers the whole problem area, offering the total solution from the grinding machine, via the TCG Unit, to the „SECU" - SynGas-Electricity energy Conversion Unit (Gas motors or Turbines,) - to the „LFU" - Liquid Fuel Unit (Fischer-Tropsh or Diesel Liquefaction) with a specific readyly available additional equipments.

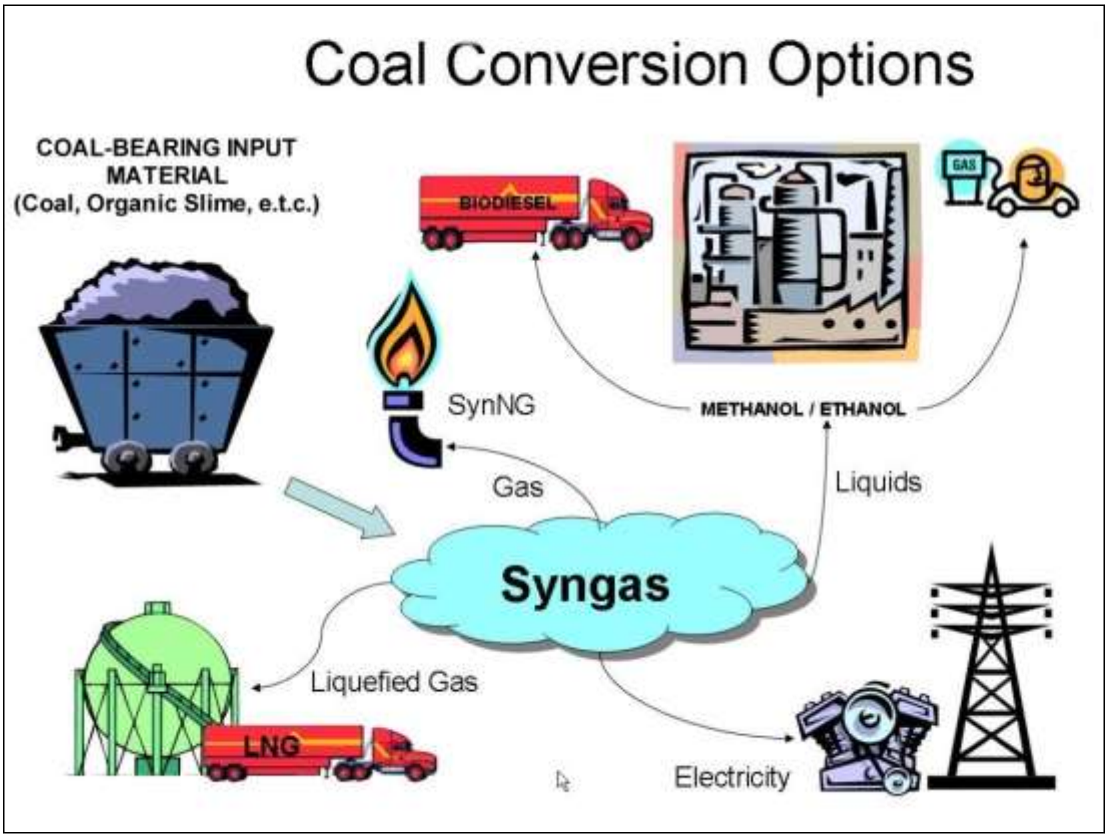


Figure 3.4.1. The result of the international analisys of alternative clean coal technologies

A solid carbonaceous material synthesis (100 million BTU/h) gas generation plant (gasifier) was built on a test site. This commercial scale reference plant was completed in mid-August 2007. Currently conducting operational start-up activities at the University of Toledo, Ohio. The plant is designed to utilize carbonaceous feedstock from coal to biomass including wood chips, rice straw, ethanol plant DDGS, and municipal and industry waste products (i.e. organic sludge, industry waste, petroleum coke) for synthesis gas production. The plant feed system is designed to handle blended feedstocks, including coal mixed in any proportion, with the above mentioned materials.

The unique capability of the plant for utilizing a mixed fuel of coal and biomass in any proportion may provide synthesis gas composition from H2:CO=1:1 to H2:CO=1:3 which is most desirable for production of synthesis fuel, such as ethanol, mixed alcohols, diesel, gasoline, and jet-fuel. (Schuetzle, et al. 2007)

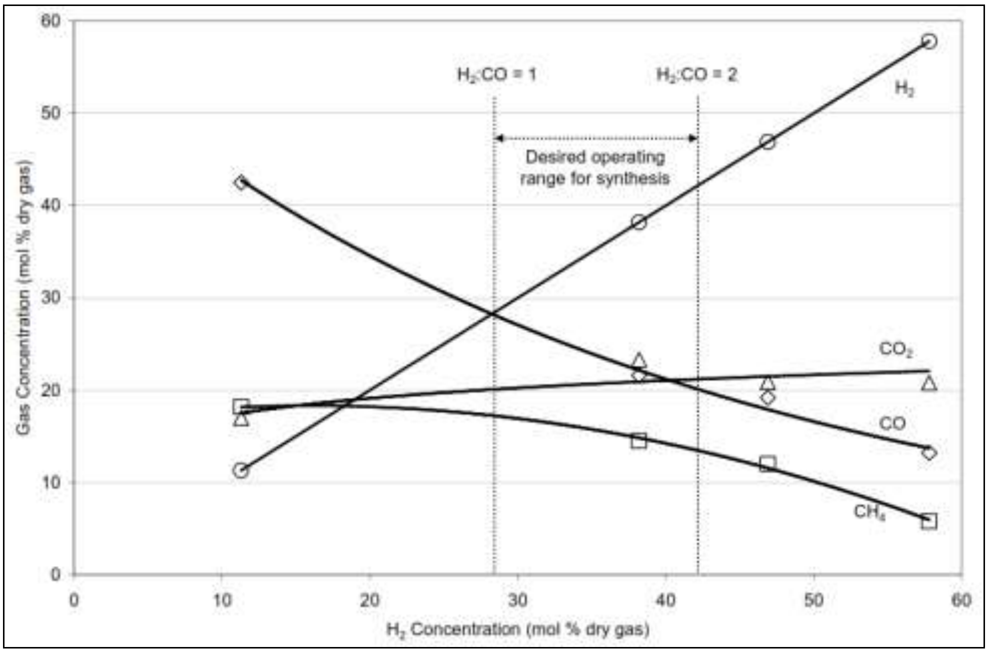


Figure 3.4.2. Syngas composition operating range for pyrolysis/steam reforming system

Syngas composition operating range for pyrolysis/steam reforming system which includes the range of H2:CO most desirable for production of synthesis fuels. Data collected on pilot scale pyrolysis/steam reforming system operated on biomass feedstock. (Schuetzle, et al. 2007)

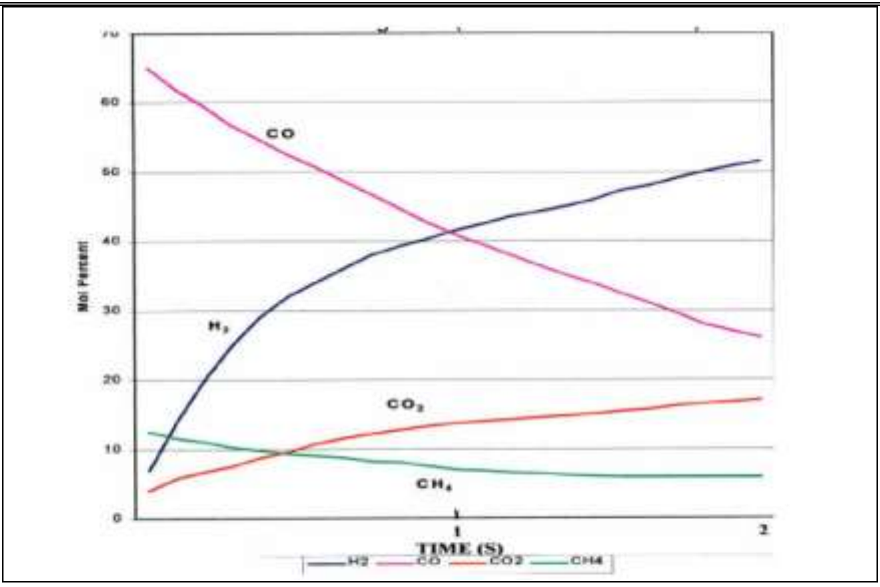


Figure 3.4.2. and 3.4.3. The quantity of the components of SynGas depending on the pressure and temperature in the pyrolysis chamber and the time length while that the feed materilal is staying in it

3.5. TCG Unit

The introductory nature and purpose of this document does not allow for specific details of the pyrolysis that was studied and described by numerous scientists through thermodynamic models and the kinetics of gasification. At the most basic level, the pyrolysis of an organic material is a thermo-chemical reaction/cracking carried out in an appropriate reaction vessel at a specific temperature in an oxygen deprived or no-oxygen atmosphere (or under inert gas atmosphere) under well-controlled conditions. The complexity of the process can be illustrated by the listing of the equations that apply in virtually all gasification processes. These are: the carbon, hydrogen and oxygen balances, the Dalton equation, the heat balance starting with the sum of the heat of formation and sensible heat of the product (s), the reaction constant of the relevant reactions, the sulfur balance, nitrogen balance, ash balance and other compounds and elements such as argon balance.

The reaction sequence for the gasification of coal or biomass has been summarized by Reimert and Schaub in 1989. Solid carbonaceous material (coal, biomass, etc.) subjected to pyrolysis results in pyrolysis gases (CO, H_2, CH_4 H_2O etc.) plus tar, oil, naphtha, plus oxygenated compounds and some char (this generally re-circulated for reprocessing), which is subjected to gas phase reactions (cracking, reforming, combustion, CO shift) and the product is the Syngas (CO, H_2, CH_4, CO_2 H_2O) and in a further process cracking products (ethanol, methanol, bio-diesel etc).

The quality and quantity as well as the exact composition of the output material depends upon the quality and composition of the input material, the type of different pyrolysis techniques and many other parameters.

The primary interest and use of the product is in an energy source capacity (gas for heating, heating or transportation diesel, or in gas motor generator sets as fuel for electricity generation) or it can be used as chemical feedstock, but is mostly used for converting the Syngas into methanol or bio-diesel, or Jet A navigation fuel. The byproduct, depending upon the feed material, can be used for soil treatment, wood treatment or as an additive in building materials.

During the thermal cracking, the governing conditions during the chemical reactions are very important. Determining factors are temperature, residence time, type of reaction processes and methods, size fraction and distribution for quality heat transfer, and many others. Perhaps the most important parameter (one that has an almost deterministic effect on the quality of the product) is the temperature in the reaction vessel and the control of the reaction kinetics. The applied temperature range in the TCG plant is relatively low (in general 450 - 520 degree C.), however most of the gasification processes and plants are operated at a much higher temperature and pressure.

The most advantageous trait of the thermal cracking or thermo-chemical reactions is that their products are mostly aromatic hydrocarbons, which have much less environmental effect than the mere incineration of carbonaceous materials.

For the treatment of the carbonaceous waste materials and for the treatment of cake created from sewage sludge dewatering the breakthrough was accomplished by the TCG by:

- the series connection of the reducing and oxidation processes
- the development and application of a specific and precise process for the oxygen portioning control in the pyrolysis process

The essence of pyrolysis based on well-controlled oxidation technology is:

- that the solid carbonaceous materials are converted into gas phase in an oxygen deprived atmosphere in the first pyrolysis chamber
- in the second phase, (with the aid of specially-constructed spiral vessels) the introduced gas and materials are subjected to steam reforming at higher temperatures that also assist in the neutralization of many environmentally harmful materials
- that the governing parameters of the gasification process during thermo-chemical reactions are controlled through a fully computerized control system

The advantages of the applied unique thermo-chemical/pyrolysis process is that the more effective gasification assures that the TCG plant will meet the most stringent environmental regulations set by both the EPA, USA and the EU. The ash/slag from the gasifier will not contain materials in a toxic form; it is vitrified, which will prevent mobility or dissolution in water. The waste product can be easily handled with other non-toxic byproducts or waste material for disposal purposes. However, in each case, it is recommended to carry out special tests on the ash or slag to assure that the handling system of the byproduct will meet Hungarian regulations.

In overall evaluation, the material balance of the thermo-chemical reaction (pyrolysis) during the gasification process can be considered very positive because it:

- significantly reduces the quantity of the produced waste byproducts
- complies with the strictest environmental regulations
- provides the most efficient energy utilization and savings

In addition to the significant environmental advantages, the system offers other advantages, such as:

- flexible expansion of the already existing system due to its modular design
- assures flexible capacity utilization and an integrated system for a variety of products

makes possible and facilitates the basis for effective and complex waste management systems with the introduction of pre-sorting of the waste materia

3.5.1. Physical dimensions

According to the preliminary design parameters, one, 500 sTPD capacity TCG UNIT will have external dimensions of 60m x 60m x 10 (14) m. This may change slightly depending upon specific site conditions or requirements. In case of more TCG Units the requested area can be decreased with 15%-25% of the total area. The total area of the 6+1 designed TCG UNITs is 18.900 sq.m.

The report compiled by the Ministry of Municipalities and Agriculture and SLR Consultants in their report entitled "Preparing an Integrated Waste Management Strategy for the Kingdom of Bahrain" in August 2005, concluded that of all the options available for waste treatment, the ones which provide the Best Practicable Environmental Option (BPEO) were:

- Initial Reception Area for pre-sorting/separation
- Separate re-cycling of the Construction Waste
- (composting of the source-separated green waste to energy to plant.
- Thermal treatment of the remaining waste and/or mcmte
- Landfill of the final residues which should account for no more than 10% by volume of the incoming waste stream

Considering the general requirements of the tender document the total area of the site is: 560.000 sq.m

The design of the buildings of the plants and the site itself is designed in the style of the local architecture, considering the environmental attribtes and the requirements of the owner.

Some pictures of earlier designed site and buildings can be seen bellow.

These pictures are only samples. The architectural style of the buildings and the site of the TCG-UC EL1500TH-TPY project will be designed in a later stage, and will be conciliated with the authorized person/representative of the government.

Fig. 3.5.1.1. Sample view of TCG-UC EL500 site

Fig. 3.5.1.2. and 3.5.1.3. The entrance

Fig. 3.5.1.4. The Garden of the TCG site

Fig. 3.5.1.5. The research and administration building

Fig. 3.5.1.6. The buildings of Pre-selection plant, and the TCG, and GTE Units

3.5.2. The TCG UNIT

The ghasification systerm is described int he Patent as follows: „Methods and apparatus may permit the generation of consistent output synthesis gas from highly variable input feedstock solids carbonaceous materials. A stoichiometric objectivistic chemic environment may be established to stoichiometrically control carbon content in a solid carbonaceous materials gasifier system. Processing of carbonaceous materials may include dominative pyrolytic decomposition and multiple coil carbonaceous reformation. Dynamically adjustable process determinative parameters may be utilized to refine processing, including process utilization of negatively electrostatically enhanced water species, process utilization of flue gas (**9**), and adjustment of process flow rate characteristics. Recycling may be employed for internal reuse of process materials, including recycled negatively electrostatically enhanced water species, recycled flue gas (**9**), and recycled contaminants. Synthesis gas generation may involve predetermining a desired synthesis gas for output and creating high yields of such a predetermined desired synthesis gas."

3.5.2.1. Background

3.5.2.2. The basic thermo-chemical reactions – The gasification chemistry

Gasification of biomass perhaps can appear deceptively simple in principle and many types of gasifiers have been developed. The production of combustible syn-gas from biomass input fuel may have attractive potential benefits perhaps such as ridding the environment of noxious waste disposal problems, possible ease of handling, and perhaps providing alternative energy production with possibly the release of low levels of atmospheric environmental contaminants. Further, cheap electricity generation and the application of the produced syn-gas as an economical energy source for the manufacture of liquid fuels may also often make gasification very appealing.

However, the biomass input feedstock which is used in gasifiers may challenge perceptions of uncomplicated design simplicity since the feedstock material may represent varying chemical characteristic and physical properties, perhaps as inherent and unique to each individual biomass feedstock material. The chemical reactions involved in gasification, relative to processing the different varieties of available biomass materials, may involve many different reactants and many possible reaction pathways. The reaction rates are often relatively high; all these variable factors may contribute to the perhaps very complex and complicating nature of gasification processes. All too often uncontrollable variables may exist that may make gasifiers hard to mass balance control and perhaps to operate satisfactorily within known preventive maintenance procedures, steady-state output constants, and manageable environmental control compliance areas.

Numerous U.S. patents have been issued relating to alternative or renewable energy technology descriptions involving gasification or syn-gas technologies. The present TCG technology perhaps may overcome many of the operational disadvantages associated with and perhaps commonplace to current and commercially viable processes involving existing gasification systems. The various types of available market updraft, downdraft, air-blown, fixed bed, fluidized bed, circulating fluidized bed, pulsed-bed, encapsulated entrained flow, and other gasification systems may often have one or more serious disadvantages that perhaps may be overcome by the present TCG technology.

In conventional gasification systems, disadvantages often may exist that may create problems in perhaps a variety of areas, including but not limited to areas such as: process control stability related to input feedstock changes, steady state loading, blockage and overall system throughput limitations; slagging potential and challenges; scale-up sizing challenges; moisture limitations; system gas and internal vapor leak challenges; carry-through impurities and contamination challenges, system plugging challenges (such as with excess char, tars or phenols); problems with generated hydrocarbon volatiles and other corrosive sulfur vapor carry-through contaminants being released into produced synthesis gas; decreased BTU energy values in final produced synthesis gas (such as due to excess CO_2, N_2, or particulate contamination); and the like.

For example, conventional gasification systems may use horizontal-plane screw for moving feedstock material, at controlled throughput feed rates, into other competitive gasification thermal reactor systems and also for simultaneously utilizing the enclosed auger pipe housing (often using more than one auger system in a one-to-the-other configuration) as an enclosed temperature stage initial devolatilization zone. However, these combined double-duty auger system designs may often be plagued with numerous and sporadic mechanical, unpredictable and uncontrollable process (negative) variables. Such variables can be considered as centering around problems associated with input feed solids that can often rope/lock disproportionally together or that can otherwise cause plugging or binding of the auger shaft, helical flights and/or blind the auger close tolerance receiver pipe cylinder openings.

This can in-turn warp the auger drive shaft into a bent and/or an elliptical configuration. Auger shaft warpage can cause a high side rotational internal friction wear and can rapidly create stress cracks in an auger-pipe cylinder housing unit. This can cause constant process pressure variation and can cause vapor leaks. Excess friction drag can also break shafts. Further, intermittent carbonaceous material bulk jams can occur whereby the throughput devolatilization reactivity can be either lost or slowed. Feedstock decomposition and devolatilization reactions can also begin to occur at the surface of the plug/jam, therefore releasing, and perhaps slowly devolatilizing, char solids, phenols, tars, surfactants and other surface chemical hydrocarbon constituents that can further liquefy and wax or seal the outer bulk-mass surface of the plug materials into an even tighter and more cementaceous plug. Incoming feedstock "plug mass" can quickly fill into and blind the relatively small cross-section diameter surface area narrower openings within typical auger screw pipe cylinder housings. This can also begin to close off the auger screw conduit that also serves as an initial devolatilization chamber.

The following chemical equations describe the processes that take place in the conversion of coal or other carbonaceous feedstock materials into synthesis gas.

Combustion with Oxygen:	$C + O_2 \leftrightarrow CO_2$
Gasification with Oxygen:	$2C + O_2 \leftrightarrow 2CO$
Gasification with Carbon Dioxide:	$C + CO_2 \leftrightarrow 2CO$
Gasification with Steam:	$C + H_2O \leftrightarrow CO + H_2$
Gasification with Hydrogen:	$C + 2H_2 \leftrightarrow CH_4$
Water Gas Shift Reaction:	$CO + H_2O \leftrightarrow H_2 + CO_2$
Methanation Reaction:	$CO + 3H_2 \leftrightarrow CH_4 + H_2O$

3.5.2.3. The basic chemical reactions of Near Zero Emission – „NZE"

NO_x Emission Control

$$CO + NO_x + H_2O \leftrightarrow O_2CNO + H_2O_2$$

Reaction creates Nitroxyl reactive ions and hydrogen peroxide vapor which provides additional quench water purification and final Nitroxyl precipitation into water filters.

Sulfur Emission Control

$$CO + SO_x + H_2O \leftrightarrow O_2CSO + H_2O_2$$

Reaction creates Sulfinoxyl reactive ions and hydrogen peroxide vapor which provides additional quench water purification and final Sulfinoxyl precipitation into water filters.

Metals Emission Control

$$O\text{-}_x + M \leftrightarrow MO_x$$

Ionized oxygen reaction creates metal oxides which are coagulated and precipitated into water filters. The Energy Mass Balance of TCG

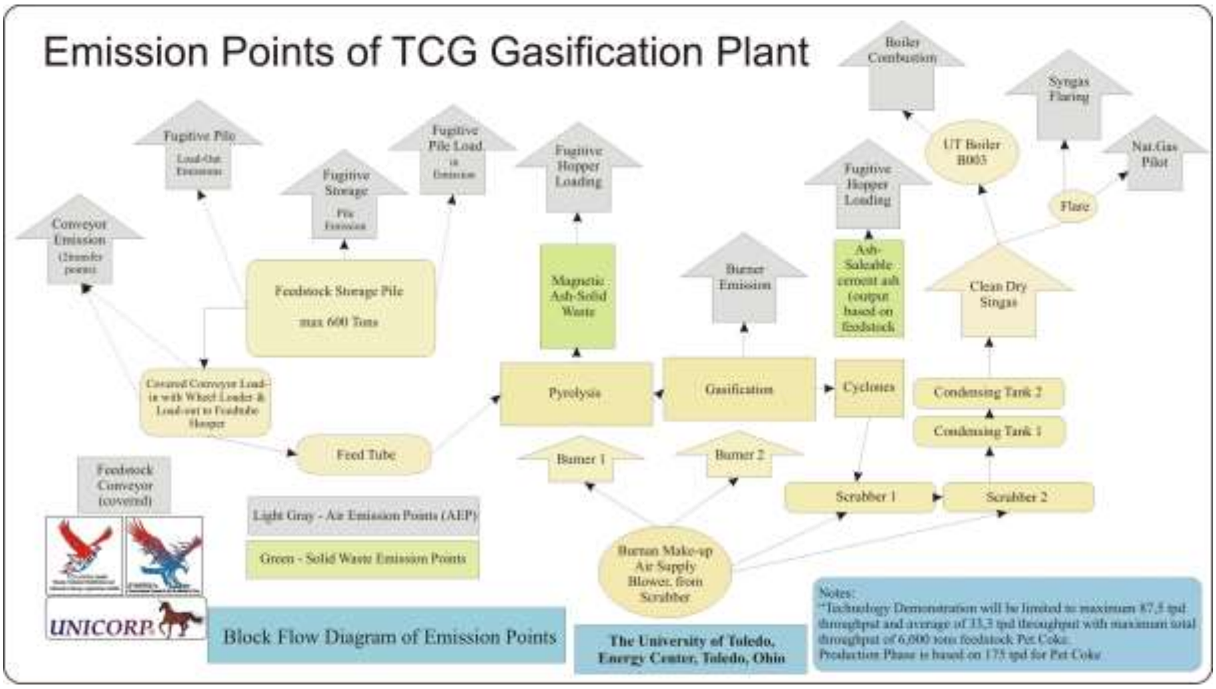


Figure 3.5.2.2.1. The visualization of energy balance and energy conversion efficiency

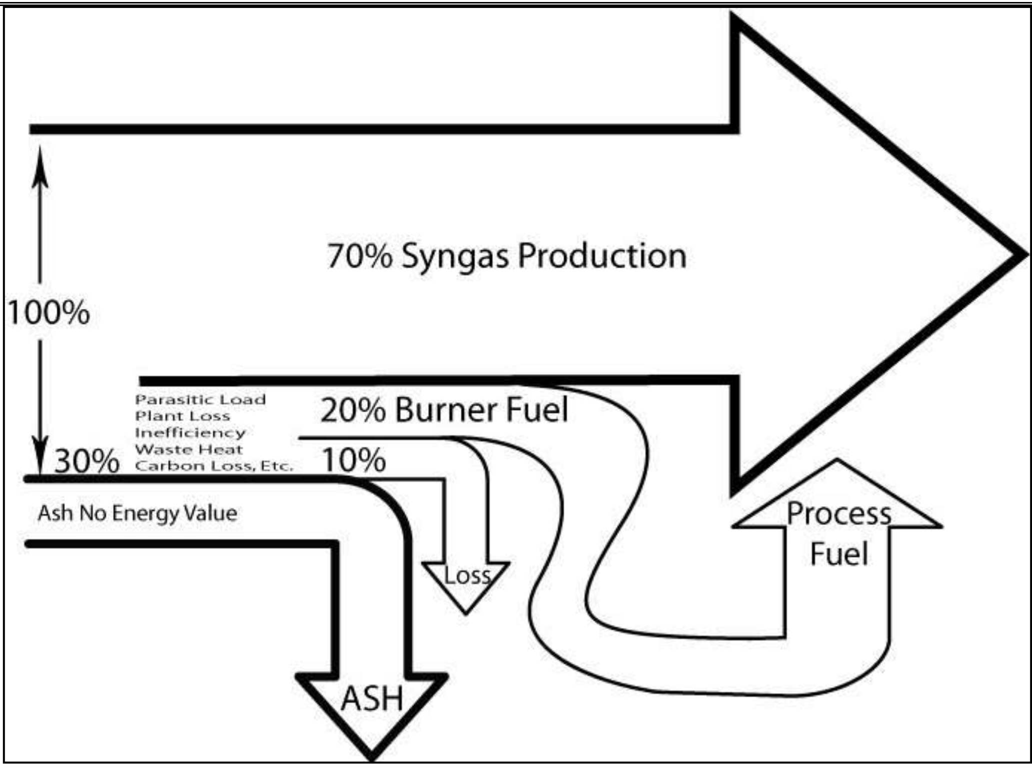


Figure 3.5.2.2.2. The visualization of energy balance and energy conversion efficiency

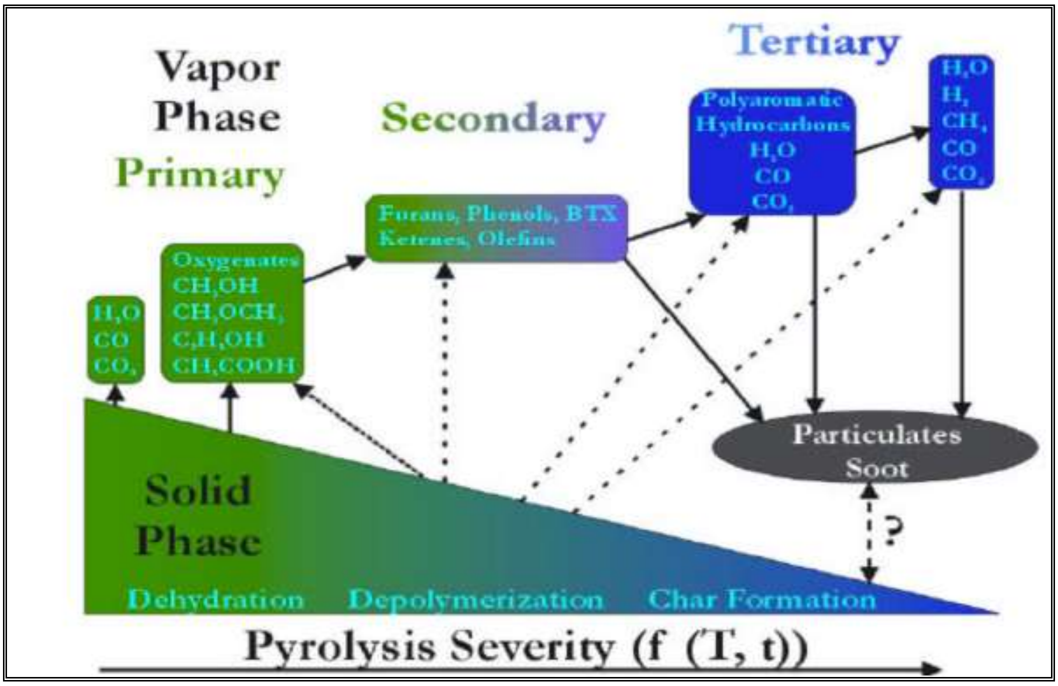


Figure 3.5.2.2.3. The Different Materials Produced in the Reaction Chamber in Function of Residence Time and Pressure.

Figure 3.5.2.2.4. és 3.5.2.2.5. The planed and the manufactured elements

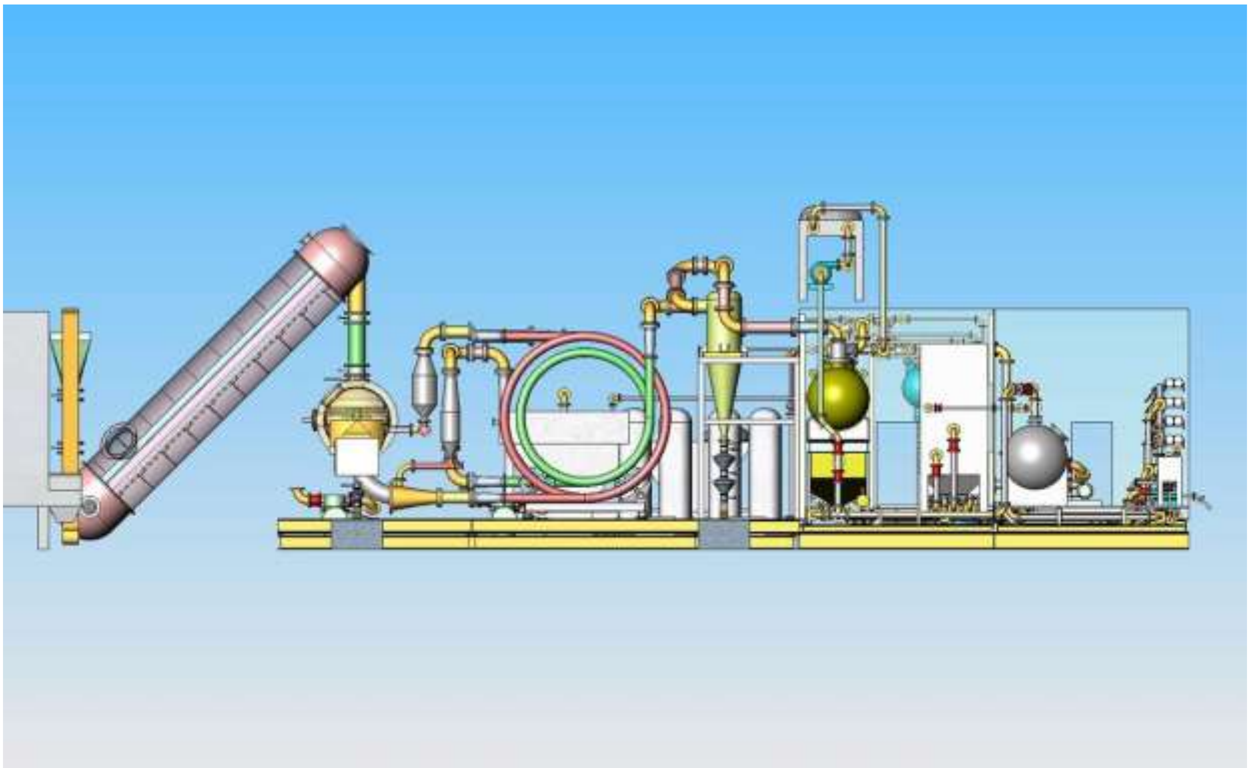


Figure 3.5.2.2.7. The TCG Unit side-view

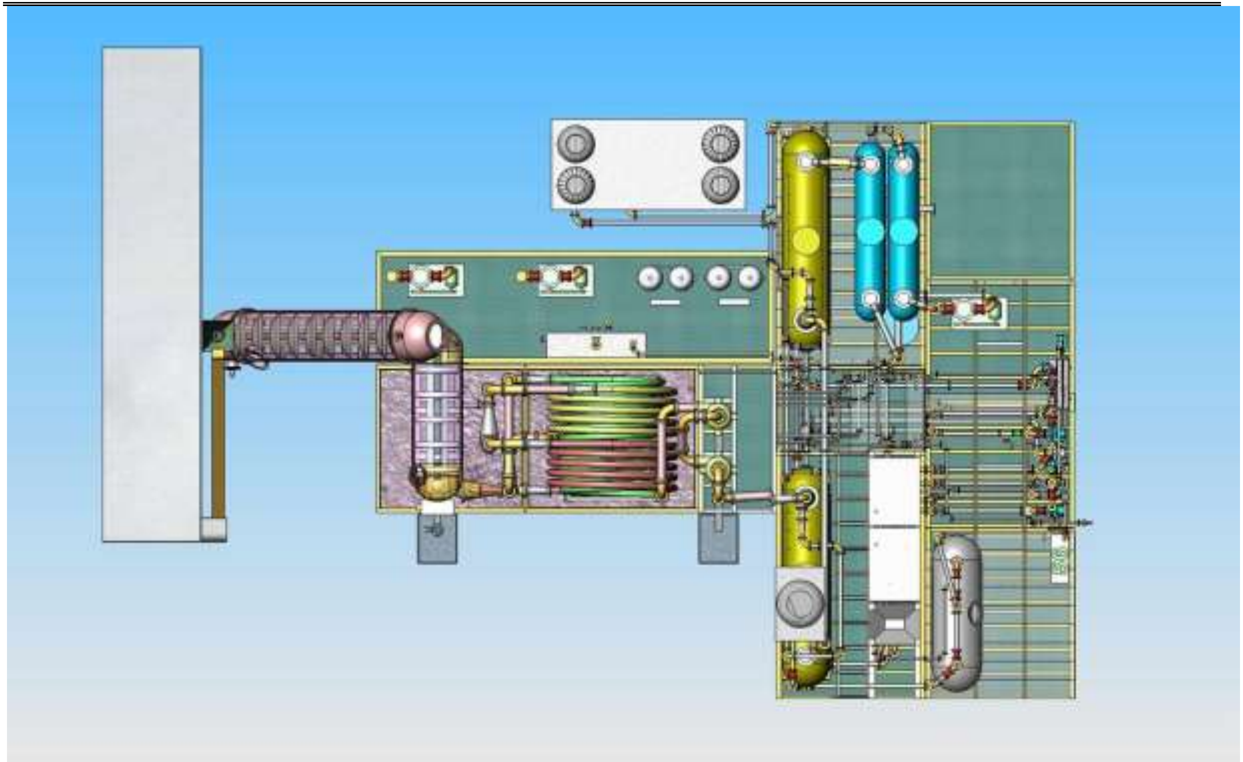


Figure 3.5.2.2.8. The TCG Unit top-view

Fig. 3.5.2.2.9. The TCG Unit under the constructing of the TCG building

During the modeling process of the TCG Plant, 90% operation availability and 95% loading capacity was used. The TCG-UC PP was designed for a continuous (7/7 and 24/24) operation, in other words, of the available yearly 8,760 total hours (365*24 hours), only 8,760*90%*95%= **7,490** working hours (312,08 days) were used. The remaining 53 days per year are allocated as a safety measure for any unforeseeable repairs and scheduled yearly maintenance. However, experience shows that unexpected breakdowns are a very infrequent occurance, and most repairs can be performed within a very short timeframe due to the maintenance-friendly design of the plant.

Also, the TCG unit has many duplicate systems that assures that, in the unlikely event of a breakdown, these redundancies are be able to handle the production process on a somewhat reduced capacity but without a complete shutdown of the plant during their replacement. The unit is well-furnished with process monitoring and controlling devices that will help to locate any problem in a very short time or, in many cases, before a complete breakdown can occur.

A detailed operation manual and maintenance process and requirements documentation will be provided to the purchaser after the successful site test and handover of the Plant to the operator/owner.

3.5.3. The feedstock

A partial list of input materials suitable for the TCG System includes: organic waste, sewage, human and animal organic sludge, plant and animal matter, municipal waste, low-grade or otherwise traditionally unsuitable coals, high grade coal, lignite, etc.

Although any carbon-based or carbonaceous material is suitable for use as an input material, the System achieves optimal efficiency when operated with mixed-source input materials. The System is capable of operating normally using single-source input material, however in this case its efficiency is dependent upon several factors. Some of the most deterministic properties of the feed material are:

- Caloric value
- The quality and quantity of ash forming minerals
- Quality and quantity of volatile matter
- Moisture content

The use of mixed-source input material may allow for the regulation of moisture content, and in so doing, ensure the optimal mole ratio of water to carbon, namely 1 : 1, which allows the TCG System to operate at optimal operation conditions.

3.5.4. The product of TCG Unit

As already noted, the TCG System intakes coal and other carbonaceous input materials, gasifies them through a process of pyrolysis, and in so doing generates as output a combustible synthetic gas containing hydrogen, carbon monoxide, carbon dioxide and methane.

The quality and quantity of the synthetic gas (Syngas) is naturally dependent largely on the quality and quantity the input materials. By careful analysis of the properties of the input materials, it is possible to determine with a great degree of accuracy the ratios, properties and amount of the synthetic gas that will result from any given input.

From an energy-generating point of view, calorific values are most important. The calorific value of a combustible material is that heat quantity which can be obtained from 1 kg of the material in such a way that the water content of the material departs with the gases in steam form. The calorific value can be calculated by deducting the evaporation heat of the water from the combustion heat of the material.

3.5.5. Water and gas cleaning system

Energy excited Singlet Oxygen molecules, if left undisturbed, will collapse back to their lower energy "inner electron orbital positions" (naturally occurring) level of Triplet Oxygen GROUND STATE; this is the existing atmospheric state that occurs for all gas vapor molecules. However, it is possible to pump specific configurations of electron-volt and/or magnetic ionization energy "continuously" into oxygen molecules, which rearrange the electron orbits into outermost further distances and produce one or more activated "ionized" EXCITED STATES *that can be sustained in time.* Similar "activation/ionization" effect can also occur with external electron-volt energy stimulus being applied upon atmospheric nitrogen gas(es) molecules, actually causing the release of electrons. Since oxygen (as does nitrogen) exhibits both magnetochemical and paramagnetic natural properties, oxygen specifically then becomes very susceptible to being activated and EXCITED/ENERGIZED by exposure to either external and intense short wavelength ultraviolet (multiple frequencies) light and/or by exposure to magnetic/reflective energies. EXCITED STATES are usually unstable and such energized gas molecules will revert or decompose quickly back to their lower energy level GROUND STATE. As they "revert back", they have to get rid of this excess absorbed electrical and/or magnetic energy (as electrons drop back into their natural inner orbitals); often this is indicated by the emission of light energy. This is the plausible explanation for the visible "red glow" associated with the [as a validity indicator] presence of SINGLET OXYGEN molecules being generated (via certain types of solution chemical reactions).

Note: Refer to the G.N. Lewis paper, "The Magnetochemical Theory" (attached bibliography).

Discussion:

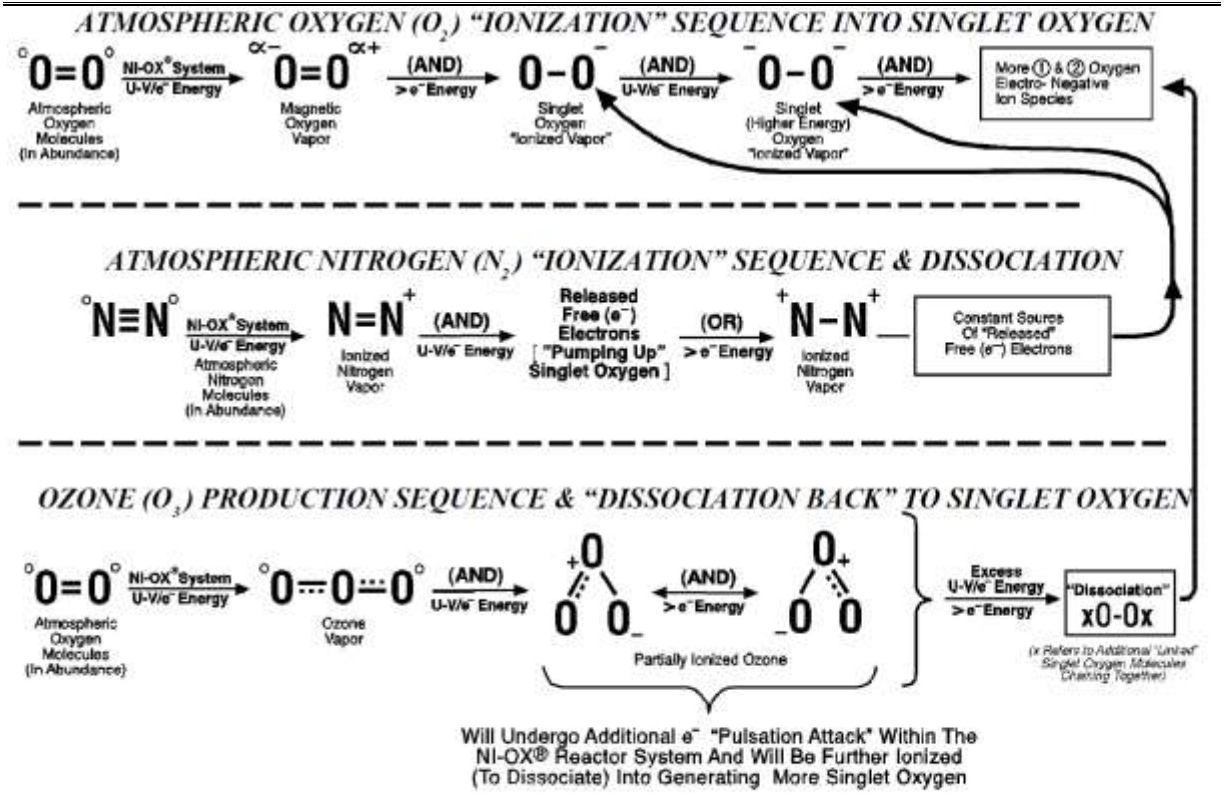
The NI-OX® Vapor Ion Generator (water treatment) coagulation and disinfection system does not employ solution chemical "generation" reactions, but does produce volumes of Singlet Oxygen molecular gas ions, via vapor space "contact" in-situ reactions with passing throughput of "air oxygen/nitrogen"! These contact generation "ionized" reactions occur within the induced electron-volt, magnetic ionization, and reflective (bounce-back) energy fields of the NI-OX® Generator. Additional/instantaneous reaction of ionized Singlet Oxygen Vapor with simultaneously generated ionized nitrogen molecules, will further co-currently interact together to produce a final stabilized and extremely reactive NITROXYL™ Ion Hybrid Group, as defined in the following discussion.

The NI-OX® (trademark refers to the production of "ionized oxygen" and "ionized nitrogen" vapor gas ions) Generator System represents a patented water treatment process equipment unit that integrates synergistic energy output components and applies unique U-V "very short wavelength" spectral, reflective ionization, pulsating electronics, and electro-mechanical "magnetization" reactor cylinder(s) design embodiments. These integrated NI-OX® system embodiments have been optimized in their configuration to generate (from both oxygen and nitrogen in air) a plethora of Singlet Oxygen "highly reactive" vapor ion species, along with reactive and ionized nitrogen species, and inclusive of secondary recombinations with atmospheric humidity water vapor, to produce (trace) additional disinfecting hydroxide(s) and peroxide(s) gas vapor ions. ***The majority of produced Singlet Oxygen vapor ions do not have any opportunity to begin to immediately re-form (convert) back to ground state "lower energy triplet electron orbit configuration" characteristic of atmosphere oxygen species.*** Since passing throughput atmospheric/air nitrogen is also co-current (ionized simultaneously) energized with U-V electron-volt and magnetic irradiation exposure within the NI-OX® reactor vessel, the ionized nitrogen vapor immediately interacts and "complexes" with the majority of the Singlet Oxygen Ion Groups and stabilizes into an aggressive and very reactive "electrophylic hybrid" vapor "coagulating/disinfecting" larger (water treatment) group, referred to as the NITROXYL™ Vapor Ions species.

The basic description of the NI-OX® Vapor Ion Generator reaction sequences, which generate said "highly reactive" coagulating and disinfecting water treatment ion vapor species groups (consisting of stable ionized oxygen/nitrogen complexes), is known as the NITROXYL™ Hybrid Ions reaction forming sequence; the simultaneous "co-current generation" sequence of NITROXYL™ Group, initial, intermediate and final forming reactions is described as follows:

I). FIRST ORDER "INITIAL" SEQUENCES (CO-CURRENT REACTIONS UPON THROUGHPUT ATMOSPHERIC AIR):

SYNERGETICS T.R.I. Corp.

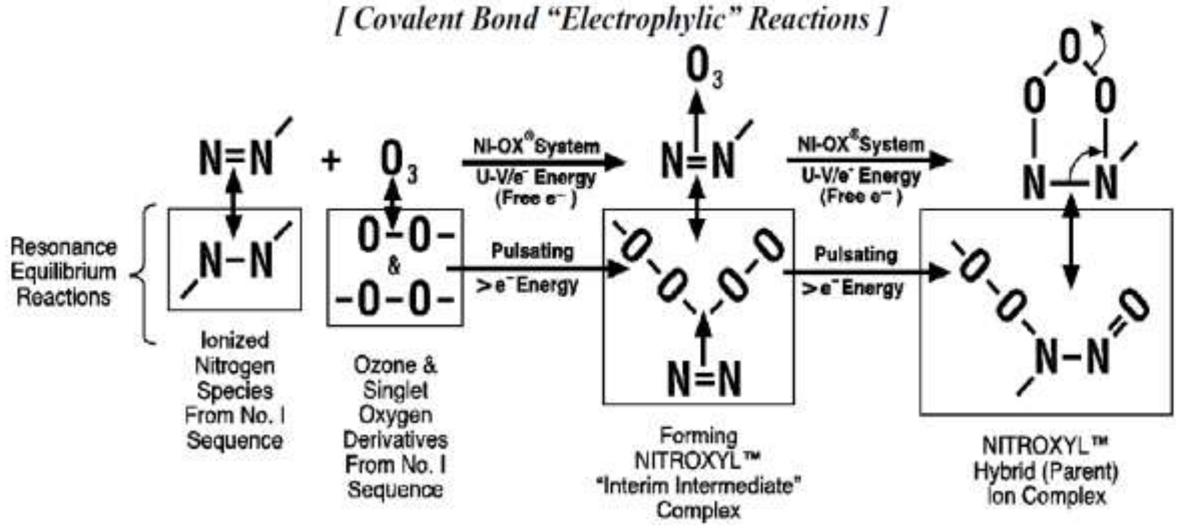


Note: Nearly all of the above NI-OX® Generator System activated ion formations and e⁻ (electron) activation(s), "initial reaction" sequences will co-currently occur and "electrophilically/ nucleophylically" bond together creating a spontaneous interaction to produce the next generation of Intermediate Reaction Order NITROXYL™ Ion(s) Sequence. Inclusive of generating a plethora of SUPEROXIDES additional Vapor Ion Plasma (VIP™) peroxides and hydroxides; all of which are extremely aggressive oxidants, coagulants, sorption agents, reductants and disinfectants. Note: Please also review the attached VIP™ Technology reaction sheet

II). INTERMEDIATE ORDER "NITROXYL™ VAPOR ION" REACTION SEQUENCES:

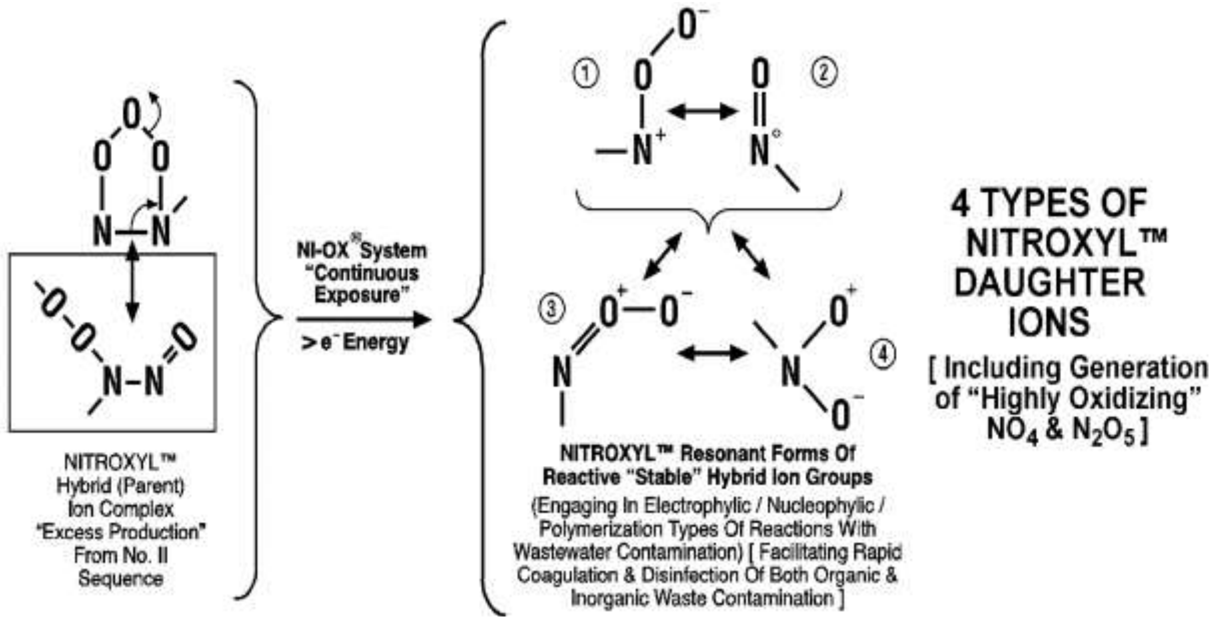
SIMULTANEOUS INTERACTION OF (INITIAL GENERATED) IONIZED NITROGEN WITH (INITIAL GENERATED) SINGLET OXYGEN & "OZONE DERIVATIVES"

[Covalent Bond "Electrophylic" Reactions]



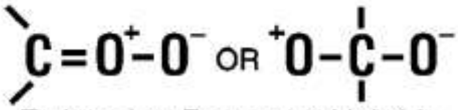
III). FINAL ORDER NITROXYL™ "DAUGHTER ION(S)" STABLE FORMATIONS:

FORMATION DISSOCIATION OF NITROXYL™ HYBRID (PARENT ION) COMPLEX STRUCTURE INTO STABLE NITROXYL™ DAUGHTER IONS



[THE NI-OX® GENERATOR SYSTEM CREATES THE PRODUCTION OF THESE NITROXYL™ DAUGHTER IONS, KNOWN AS THE CREATION OF "NITTER VAPOR ION PLASMA" FOR WATER TREATMENT]

The above defined (stable formation structure) of NITROXYL™ Daughter Ions has been called/trademarked *"Nitter Plasma" Water Treatment Ions, since the Daughter Ion basic bond structure closely resembles the highly reactive (water treatment) "Complex Ion Group" of carbon and oxygen electrophilic stable structures known as <u>Zwitter Ions.</u>*

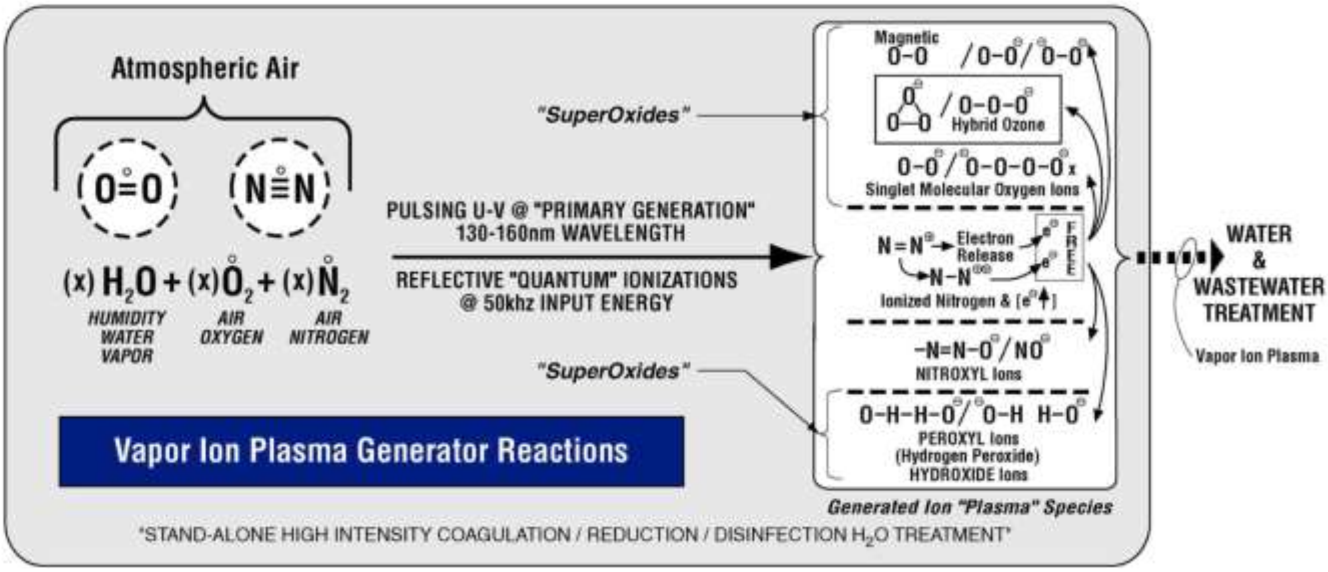


Zwitter Ion Resonant Hybrids

NOTE: The 'N' in Nitter references the various nitrogen (and oxygen) combinations that the NI-OX® Vapor Ion Generator produces, as similar to the structure of the Zwitter Ion [as known in ozone chemistry formations], but replacing C (carbon) with N (nitrogen) that has been ionized.

<u>Technical references:</u>

Refer to the text references and cited Bibliogrphy for Singlet Molecular Oxygen; refer to the R. Higgins, C. Foote, and H. Chang paper, "Chemistry of Singlet Oxygen"; refer to the C. Foote and J. Wei-Ping paper, "Chemistry of Singlet Oxygen"; refer to the "Ozone" Bibliography texts and papers discussion (as attached); the "NITROXYL™" Ion is a hybrid/alternate form of the Ozone-Zwitter Ion complex wherein ionized nitrogen has replaced the central carbon atom position (as the NITROXYL™ Ion structural description has been derived and defined by Dennis J. Johnson), whereas the trademark name "NITTER™" Plasma has been coined by Dennis J. Johnson, CEO/President - ALPHA/OMEGA Environmental, Inc.

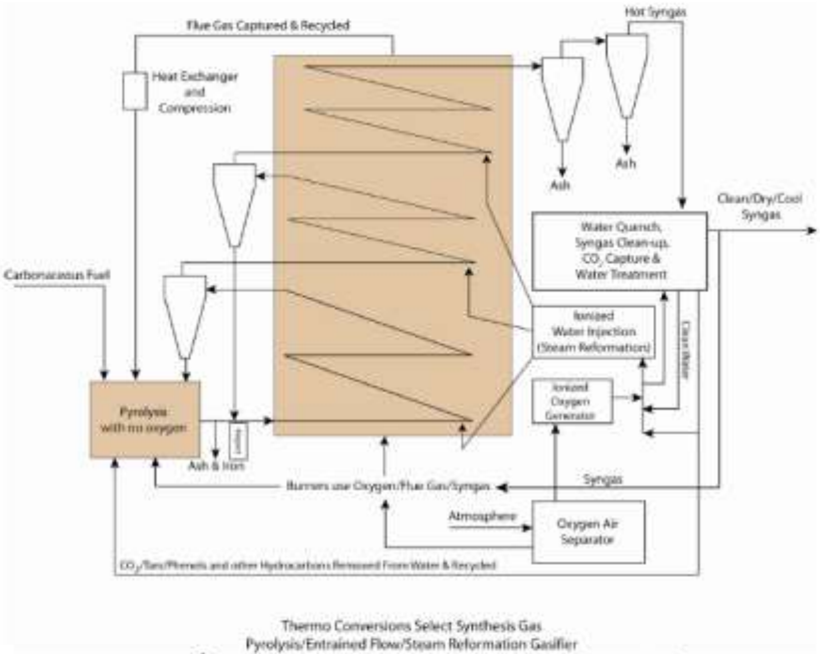


NOTE:

Please refer to the 17th volume of the 7th edition of the McGraw-Hill *Encyclopedia of Science & Technology* as relative to the "existence of SuperOxide Chemistry (types of species)" on pages 667 & 668; please contact EnerOX pertaining to volumes of university and R&D studies per the existence of Singlet Molecular Oxygen Ion(s) reactivity categorized as "SuperOxide Chemistry".

"ACCELERATED COGULATIONS / DISINFECTIONS & BOD / COD REMOVAL OXIDATIONS"

2. A TCG technológia röviden



Ábra A termo-kémiai átalakítás folyamatai

Figure 3.5.5.1 The water and gas cleaning system

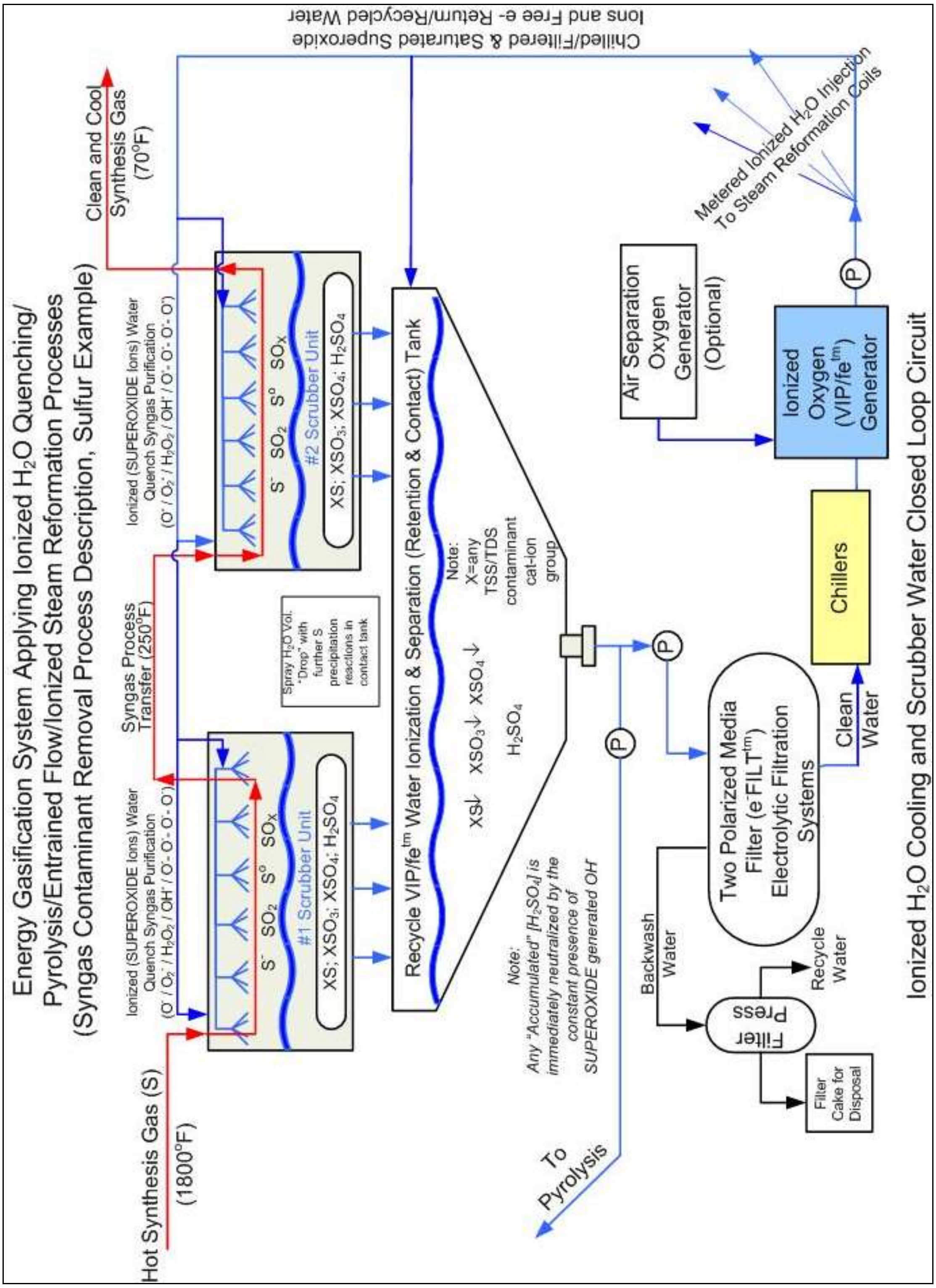


Figure 3.5.5.2 The water and gas cleaning system

3.5.6. Drawings

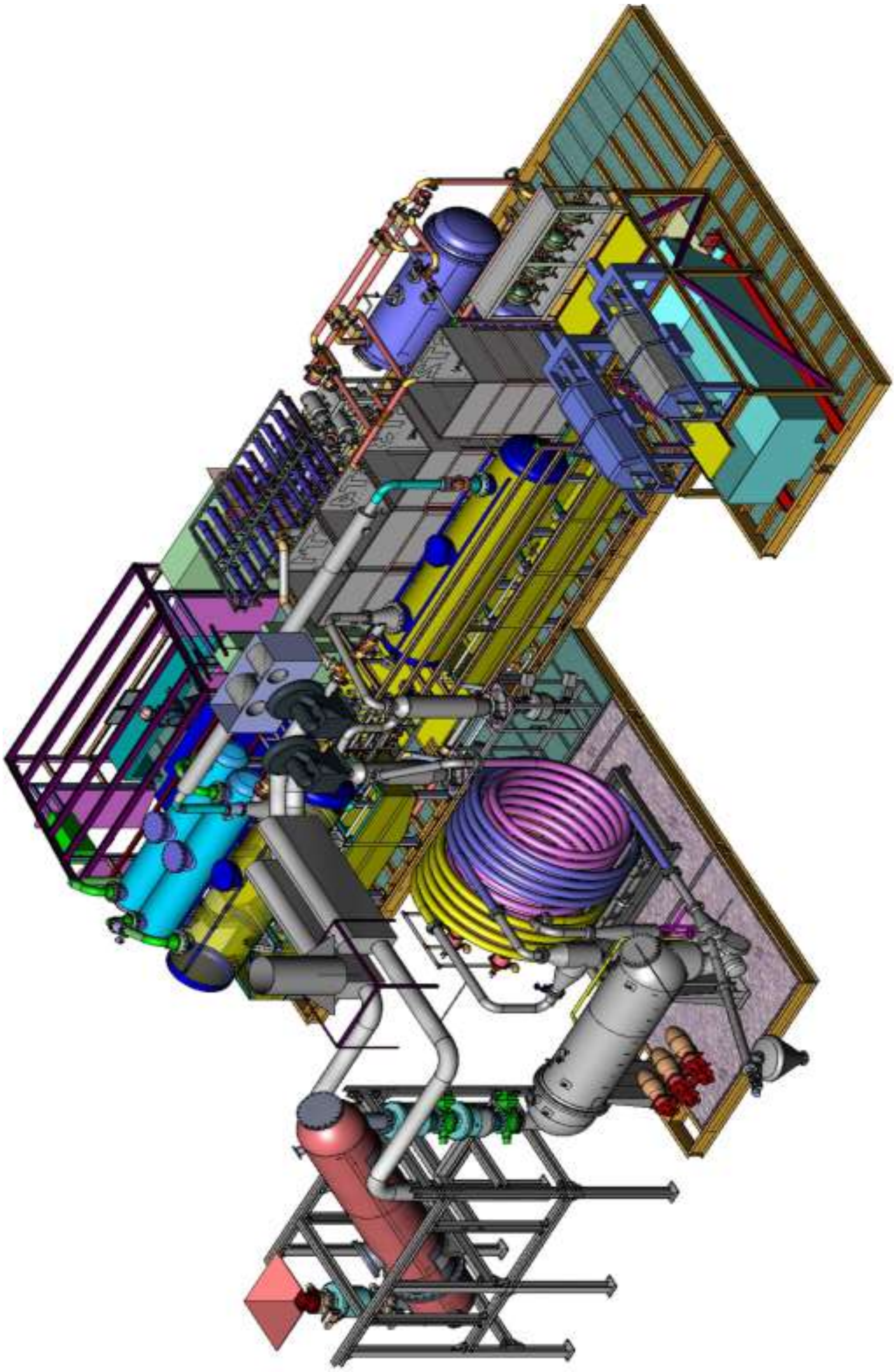


Figure 3.3.6.1. The TCG Unit isometric view

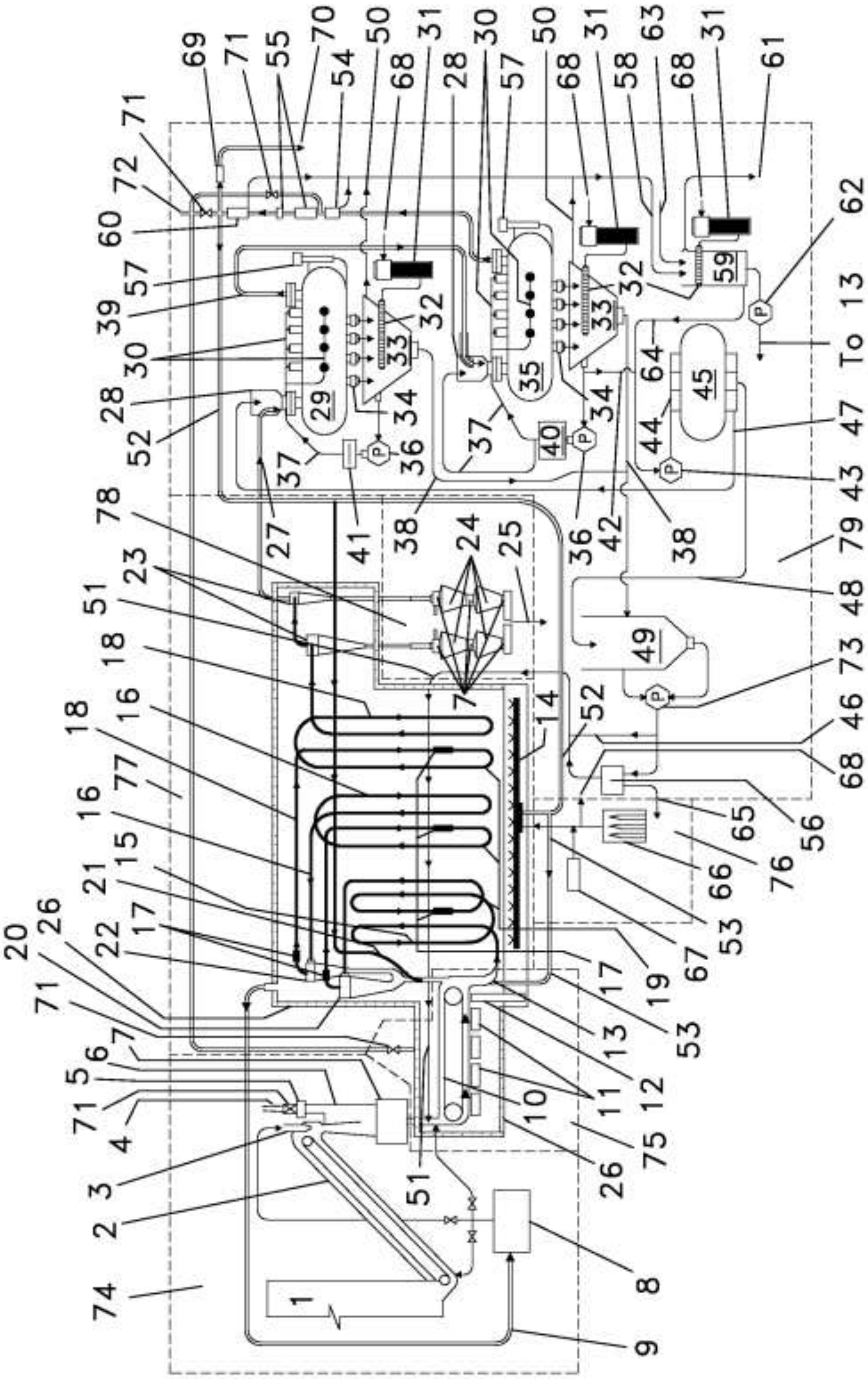


Figure 3.3.6.2. Conceptual view of a gasifier process flow path with delimited functional areas in one embodiment. I.

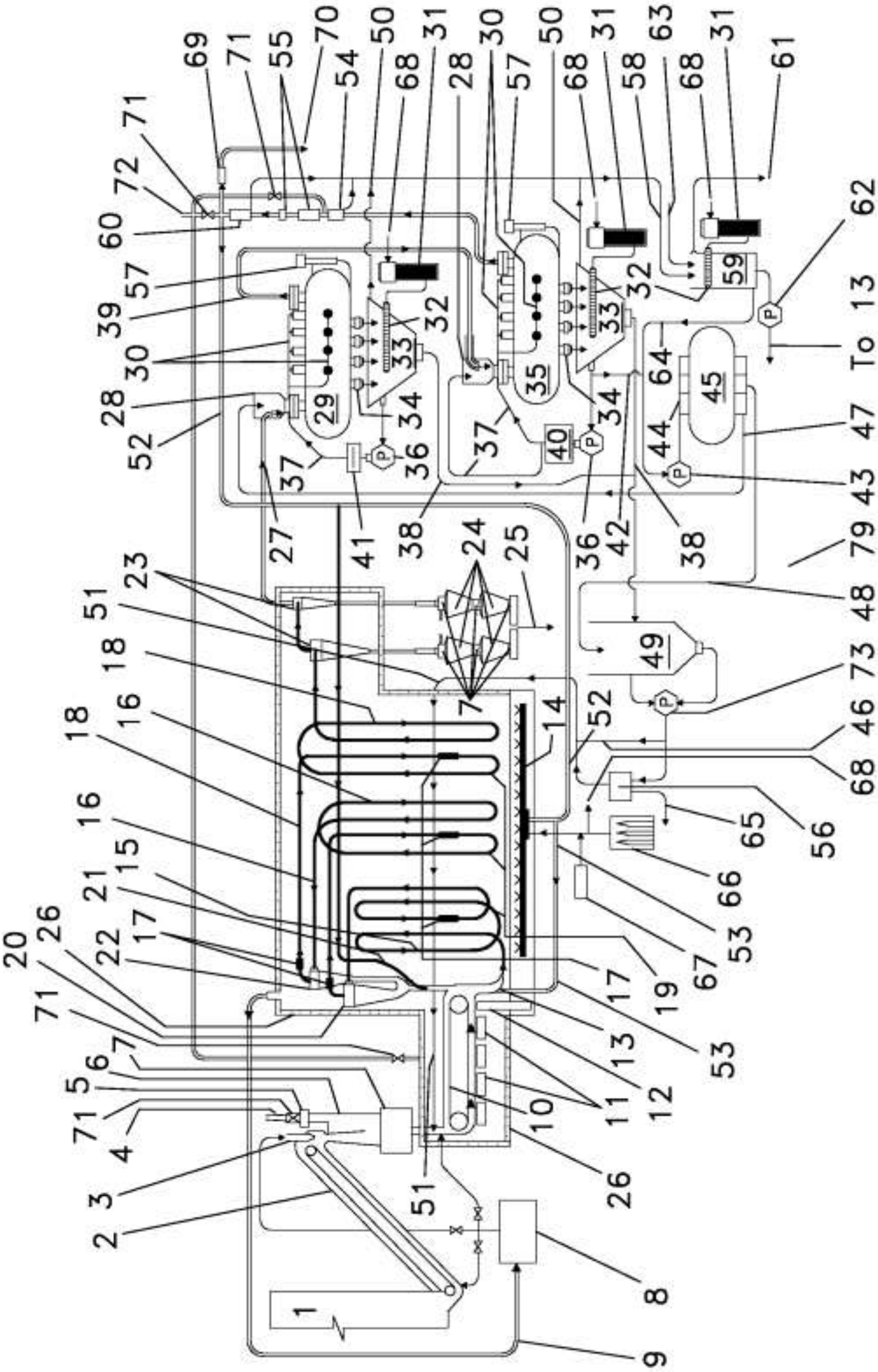


Figure 3.3.6.3. Conceptual view of a gasifier process flow path without delimited functional areas in one embodiment II.

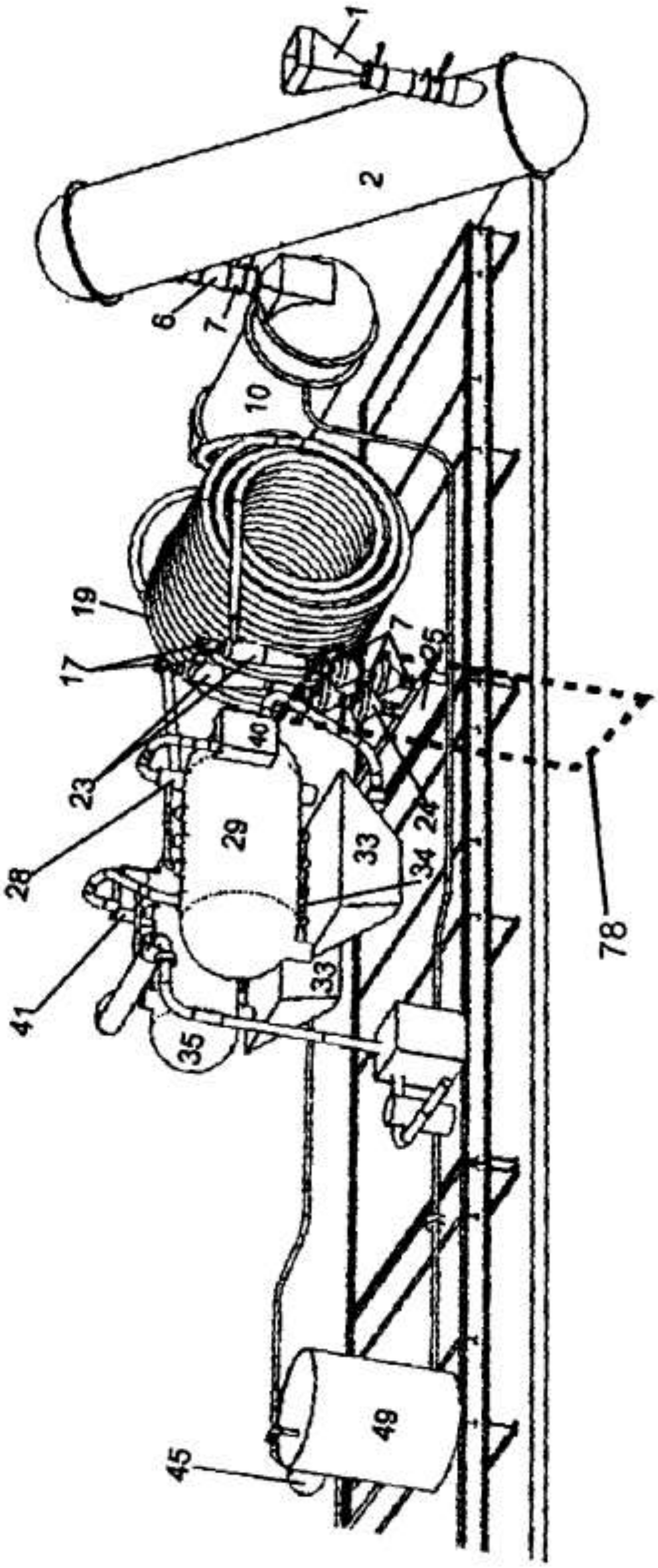


Figure 3.3.6.4. Front perspective view of a solid carbonaceous materials gasifier system in one embodiment.

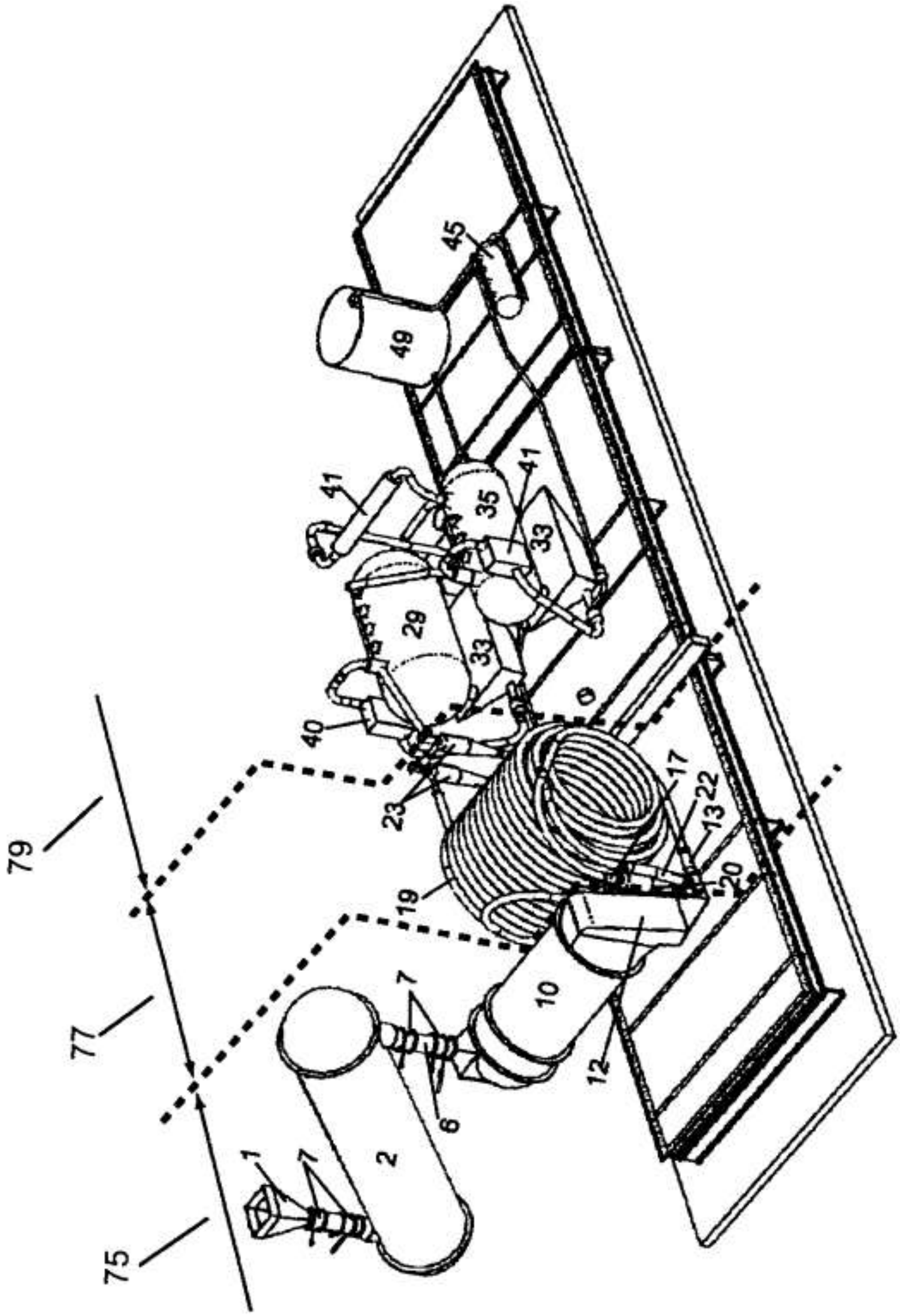


Figure 3.3.6.5. Rear perspective view of a solid carbonaceous materials gasifier system in one embodiment

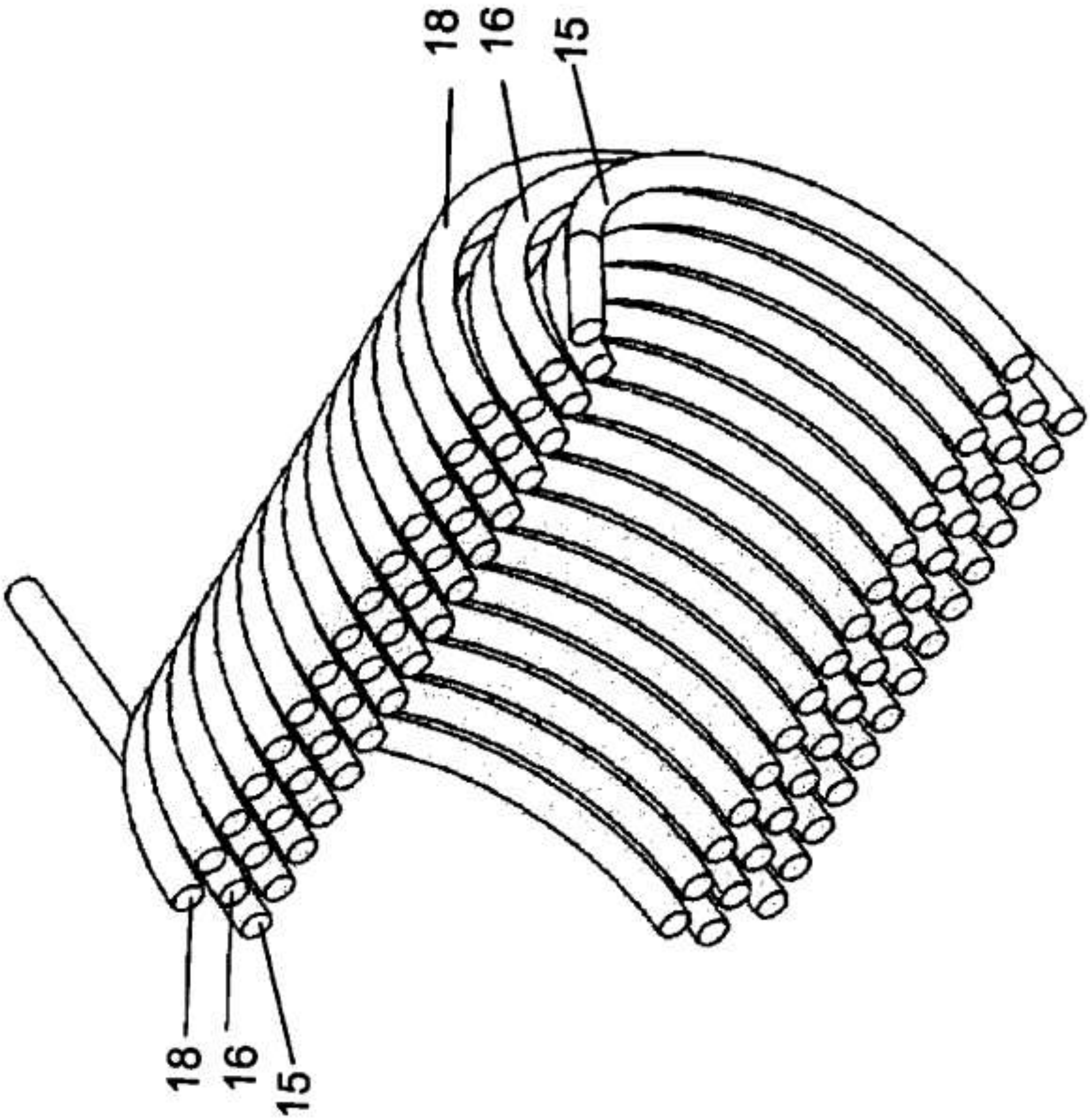


Figure 3.3.6.6. Sectional cutaway view of a multiple coil carbonaceous reformation vessel in one embodiment

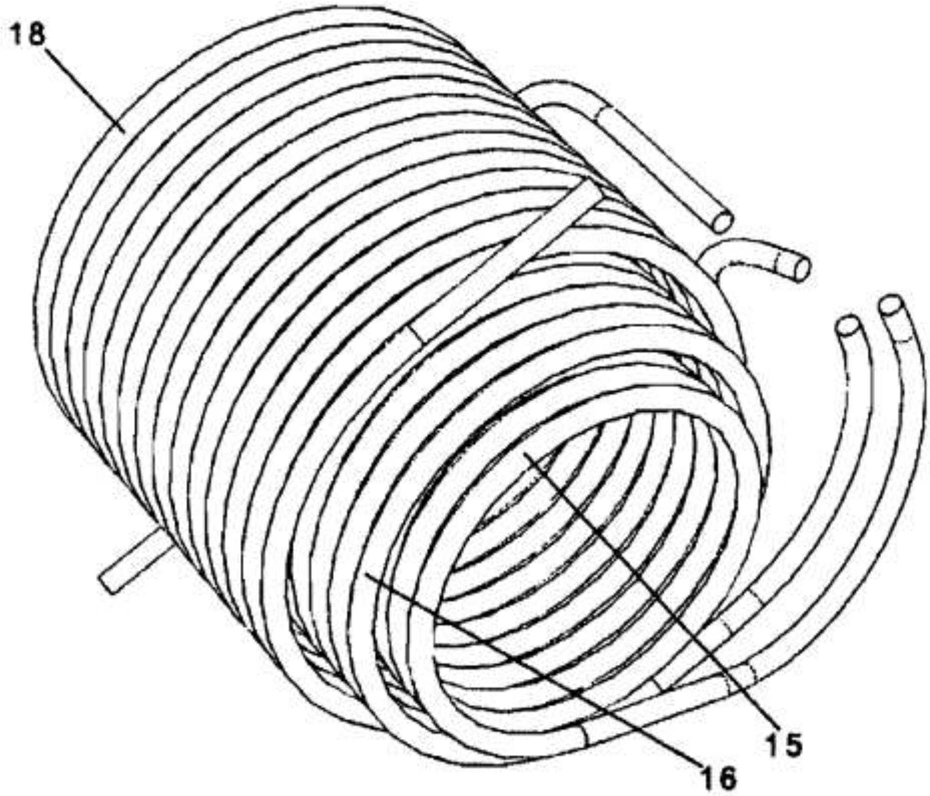


Figure 3.3.6.7/A Perspective view of a multiple coil carbonaceous reformation vessel in one embodiment

Figure 3.3.6.7/B The manufactured multiple coil

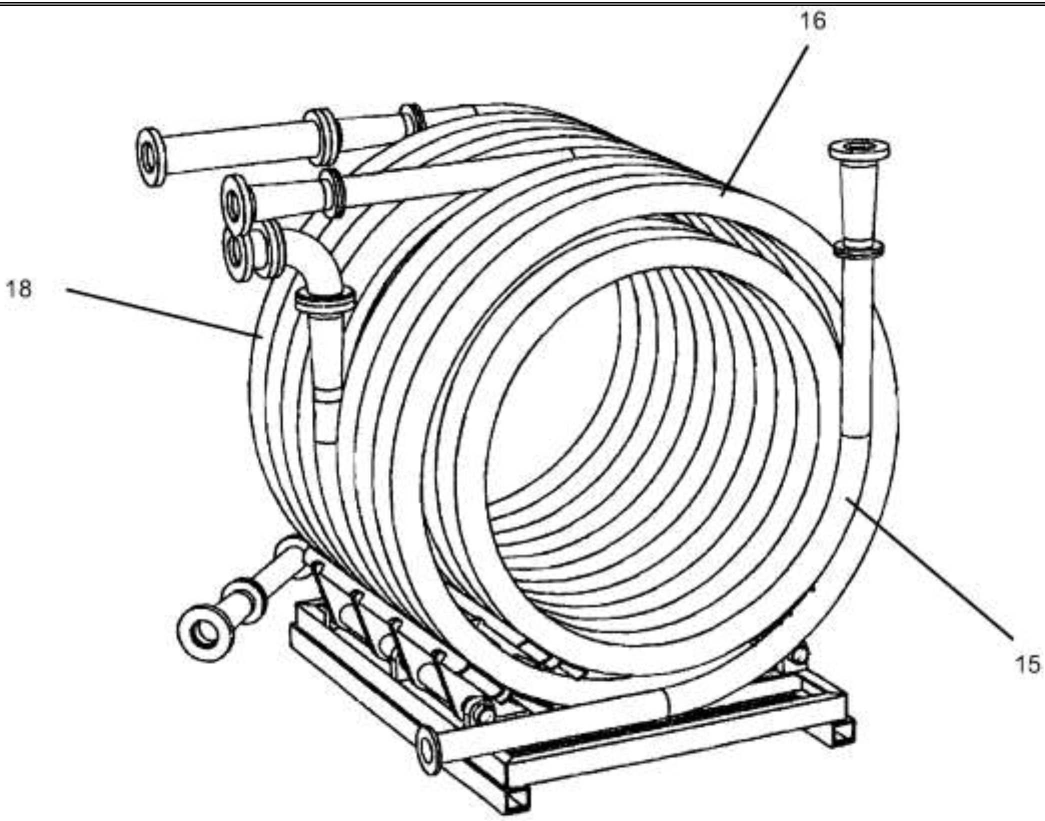


Figure 3.3.6.8/A Perspective view of a multiple coil carbonaceous reformation vessel in one embodiment

Figure 3.3.6.8/B Perspective view of a multiple coil carbonaceous reformation vessel in one embodiment

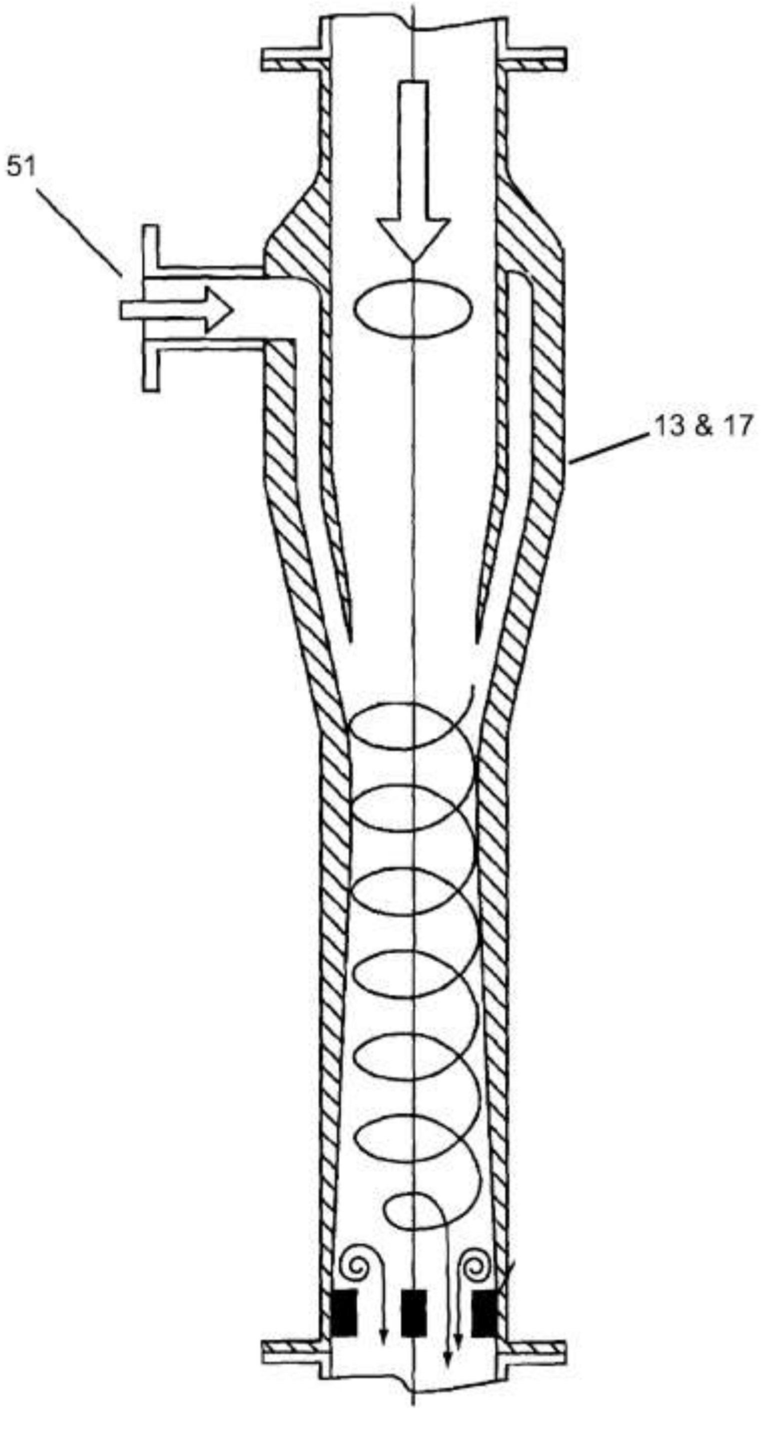


Figure 3.3.6.9. Side cutaway view of a venturi injector in one embodiment

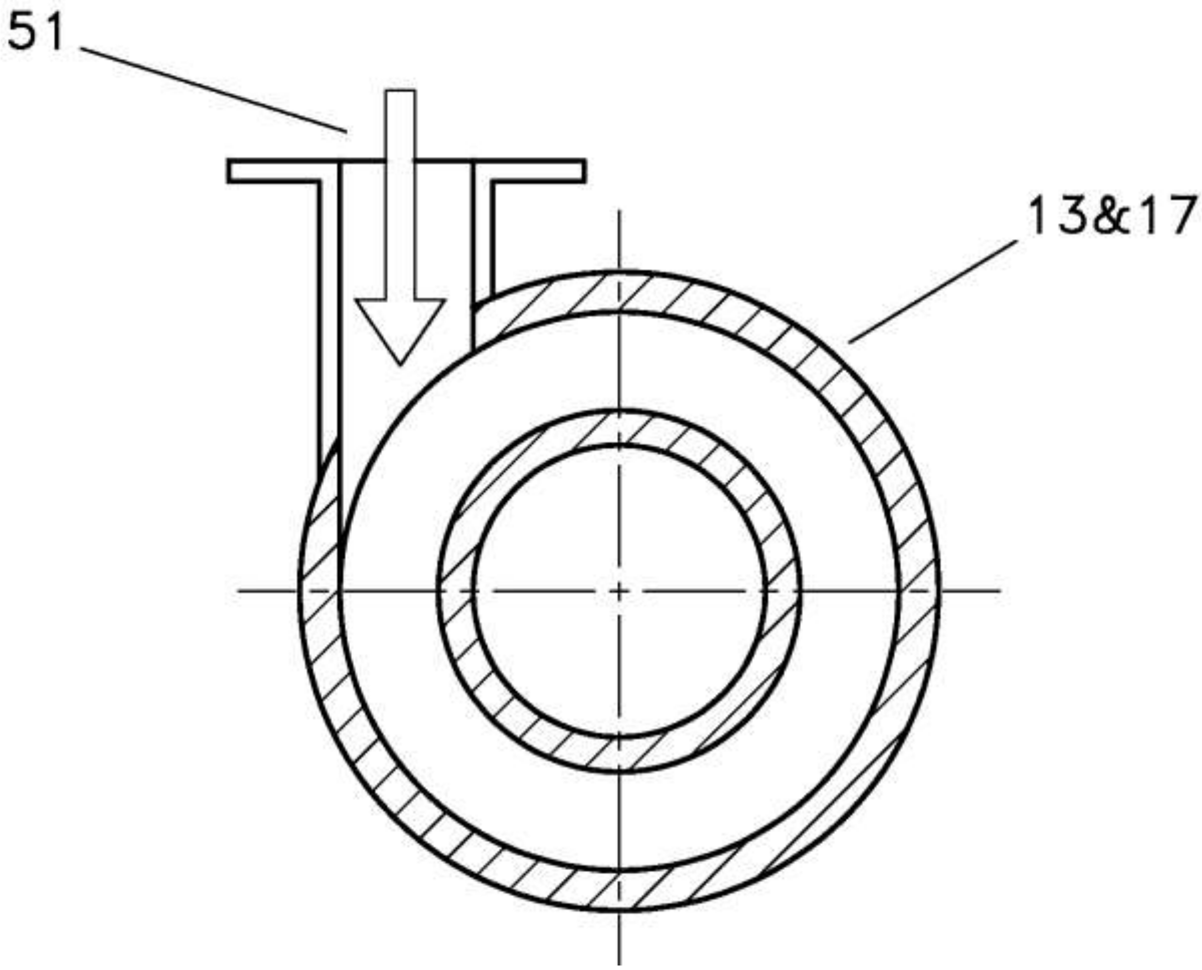


Figure 3.3.6.10. Cross section view of a venturi injector in one embodiment

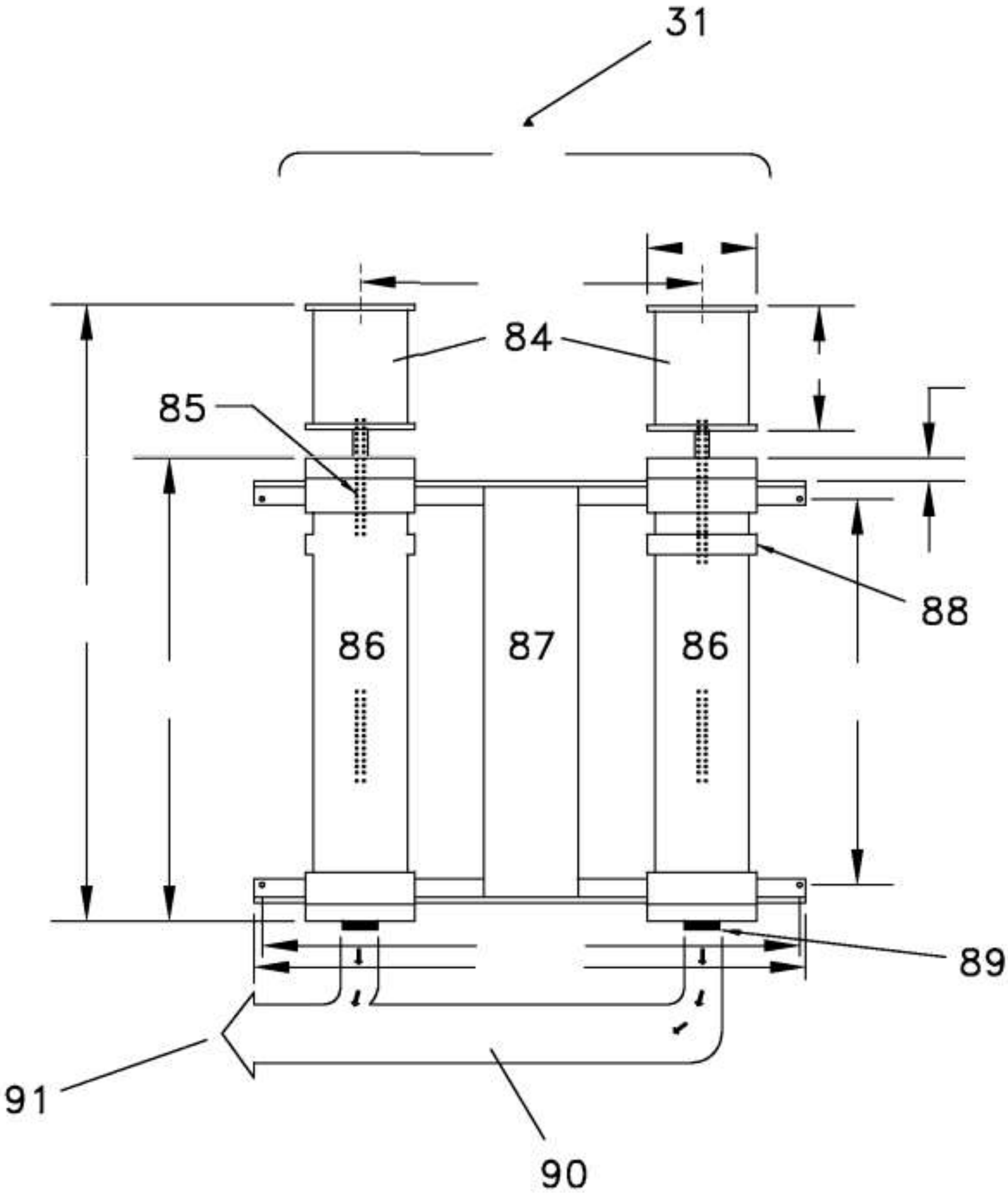


Figure 3.3.6.11. Diagrammatic view of a negatively electrostatically enhanced water species generation unit in one embodiment

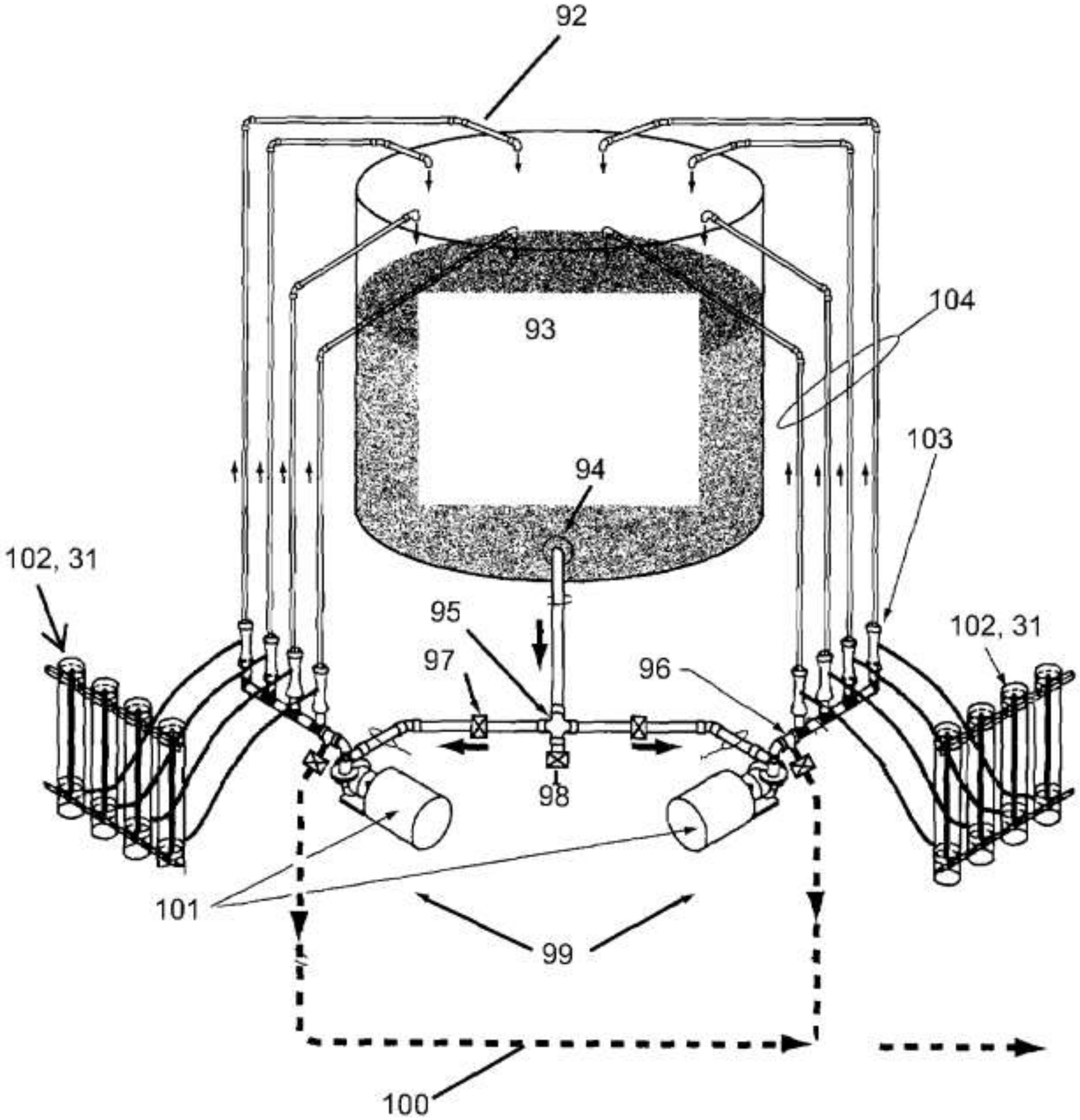


Figure 3.3.6.12. Diagrammatic view of a select product gas components scrubber in one embodiment

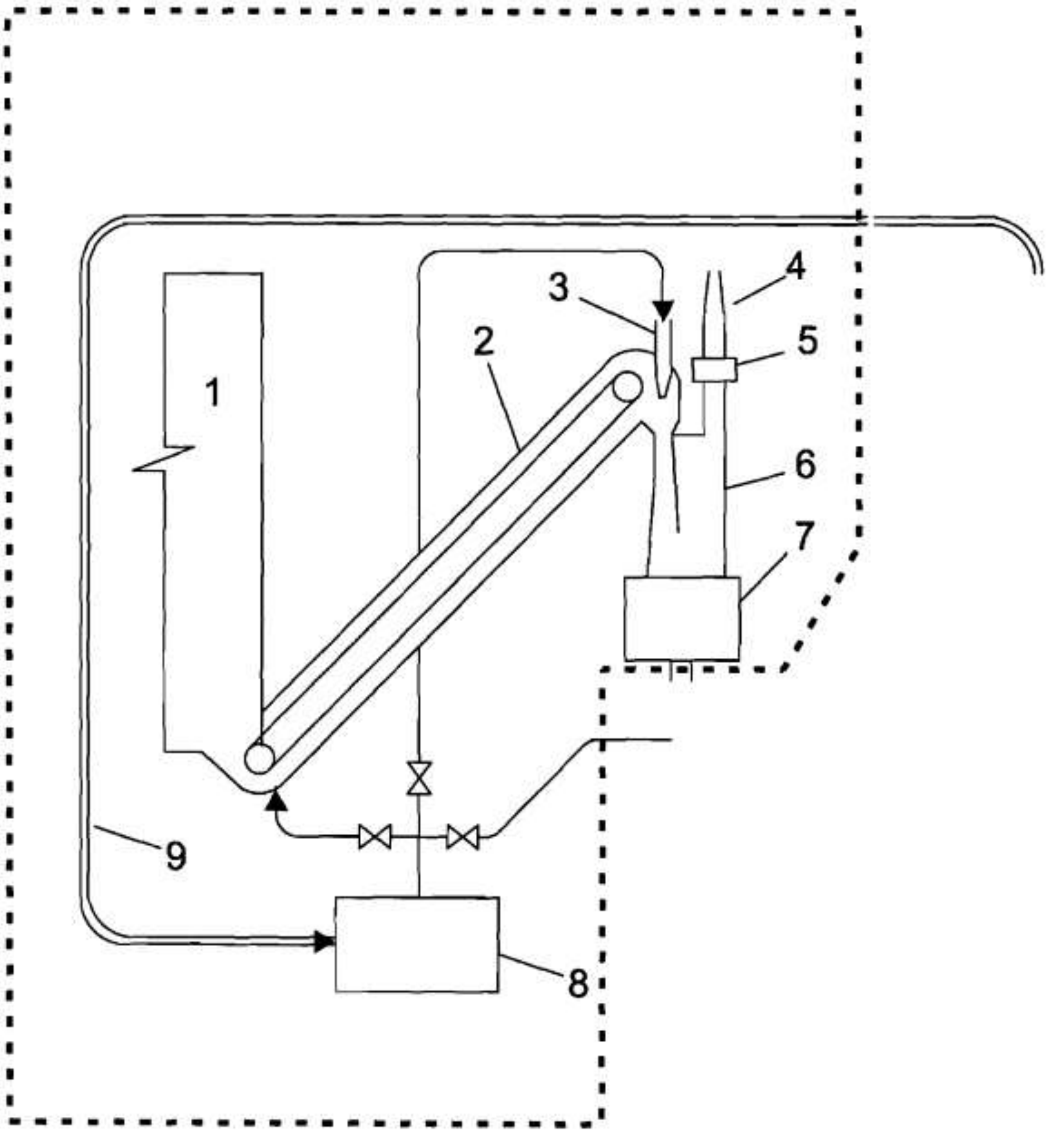


Figure 3.3.6.13. Conceptual view of a pretreatment area of a solid carbonaceous materials gasifier system in one embodiment

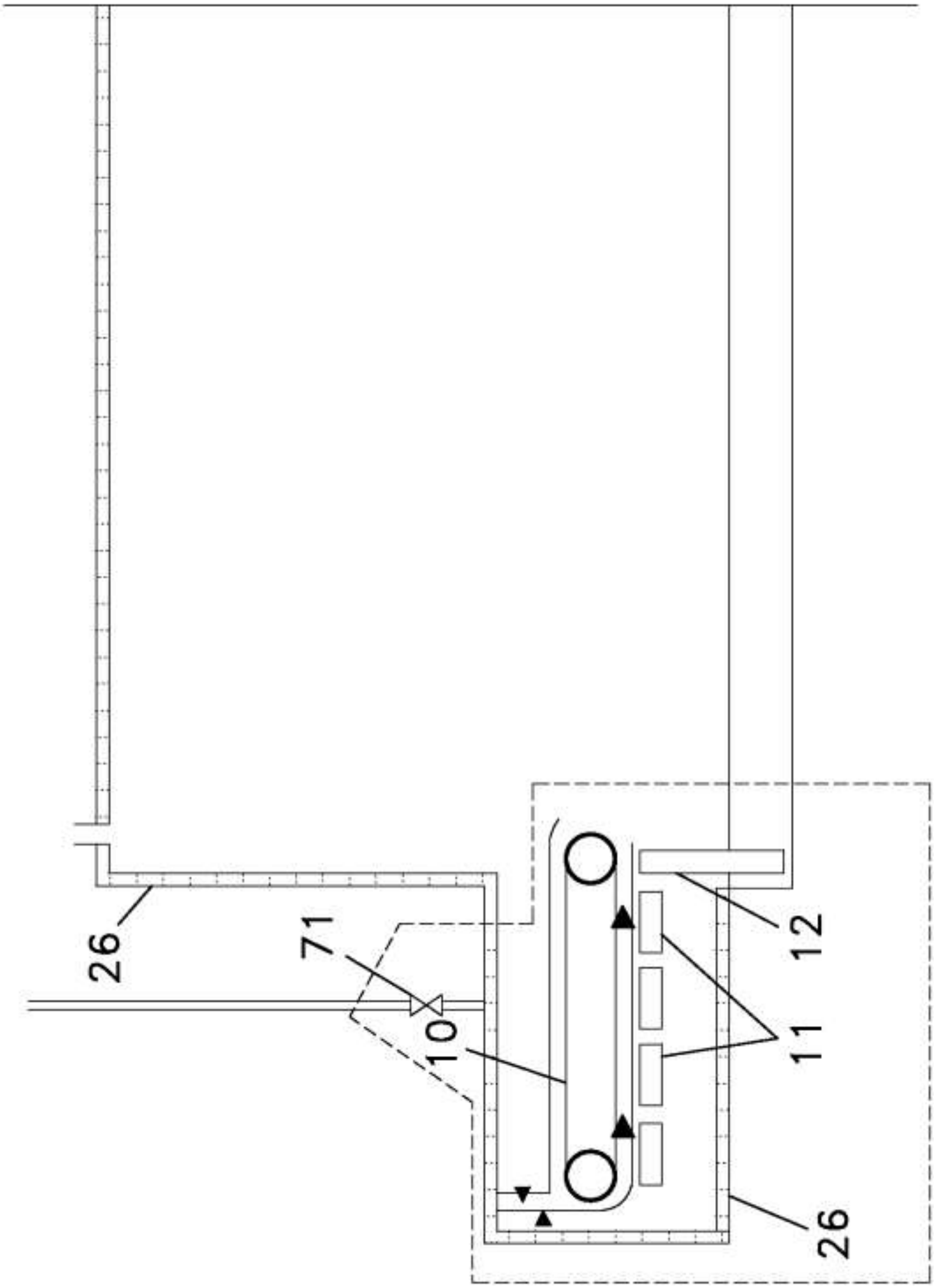


Figure 3.3.6.14. Conceptual view of a pyrolytic decomposition area of a solid carbonaceous materials gasifier system in one embodiment

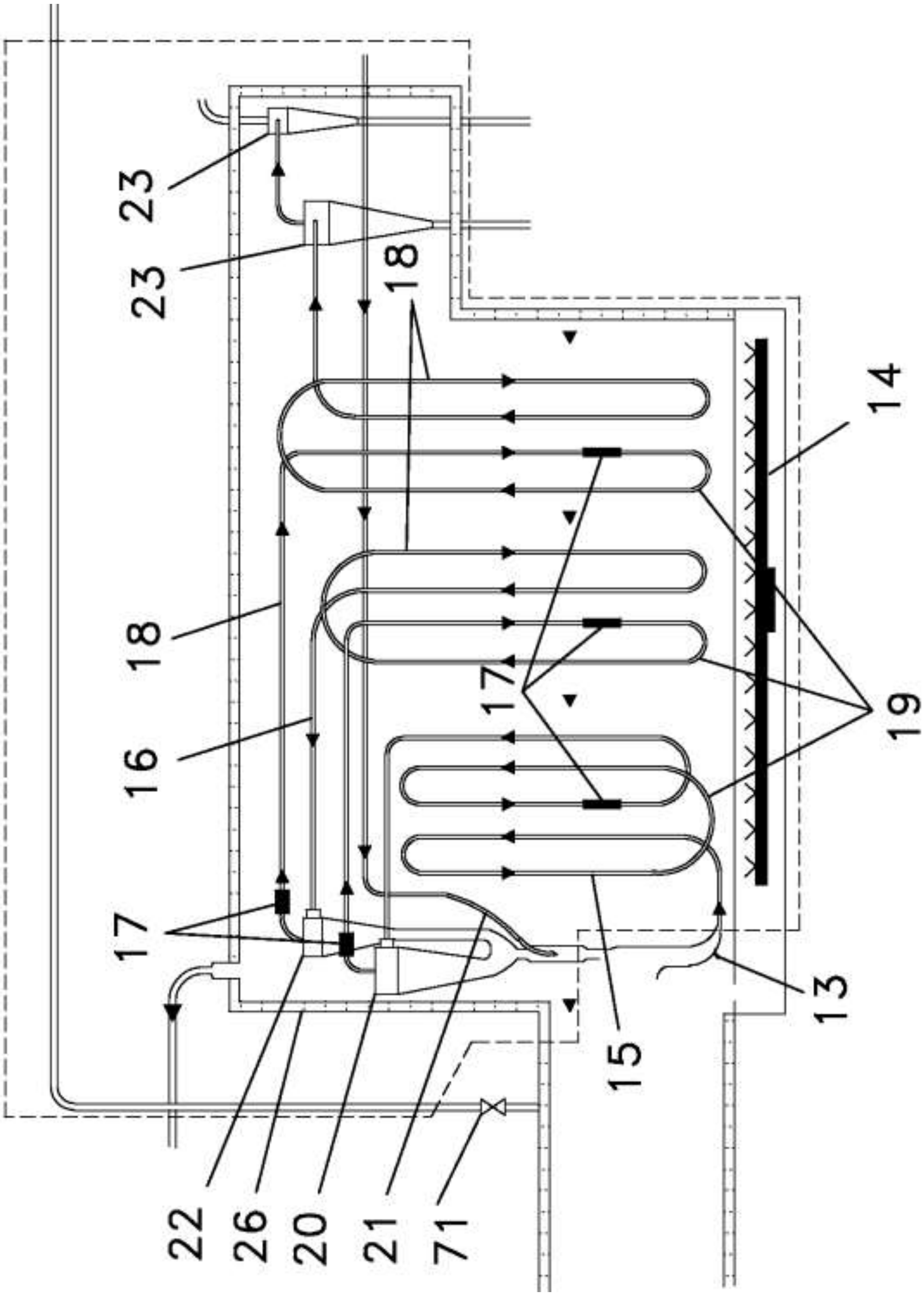


Figure 3.3.6.15. Conceptual view of a carbonaceous materials reformation area of a solid carbonaceous materials gasifier system in one embodiment

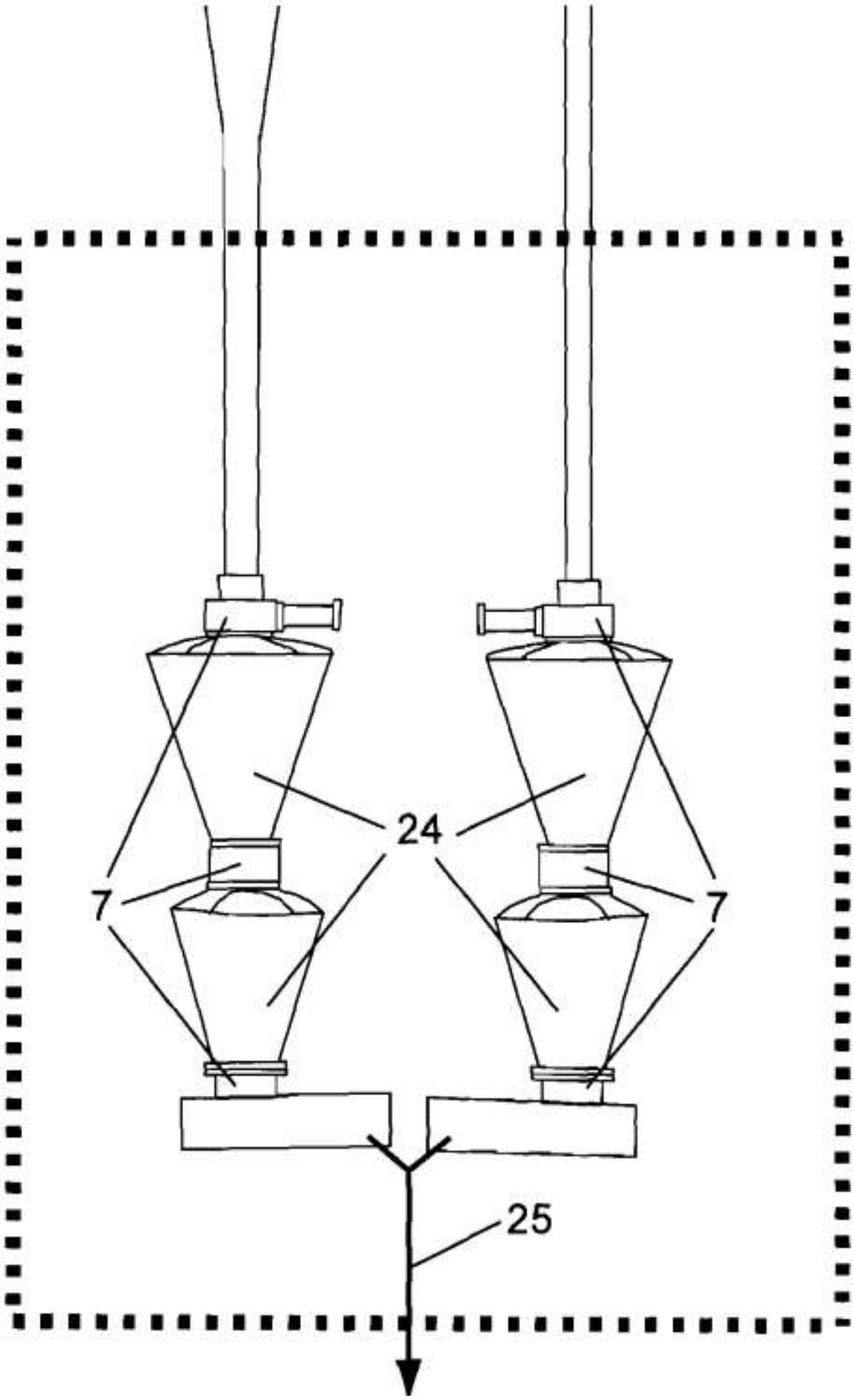


Figure 3.3.6.16. Conceptual view of an ash removal area of a solid carbonaceous materials gasifier system in one embodiment

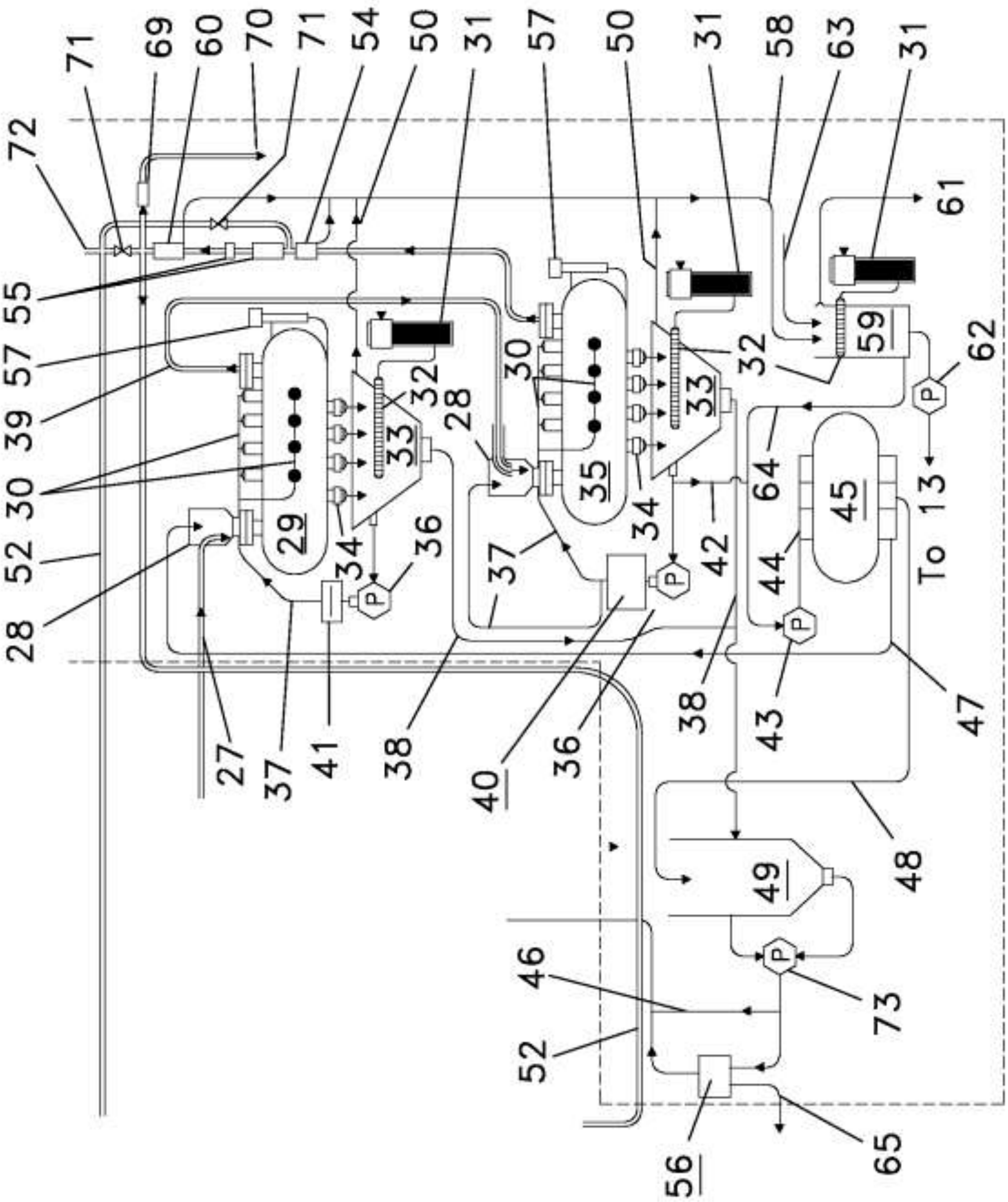


Figure 3.3.6.17. Conceptual view of a scrubber area of a solid carbonaceous materials gasifier system in one embodiment

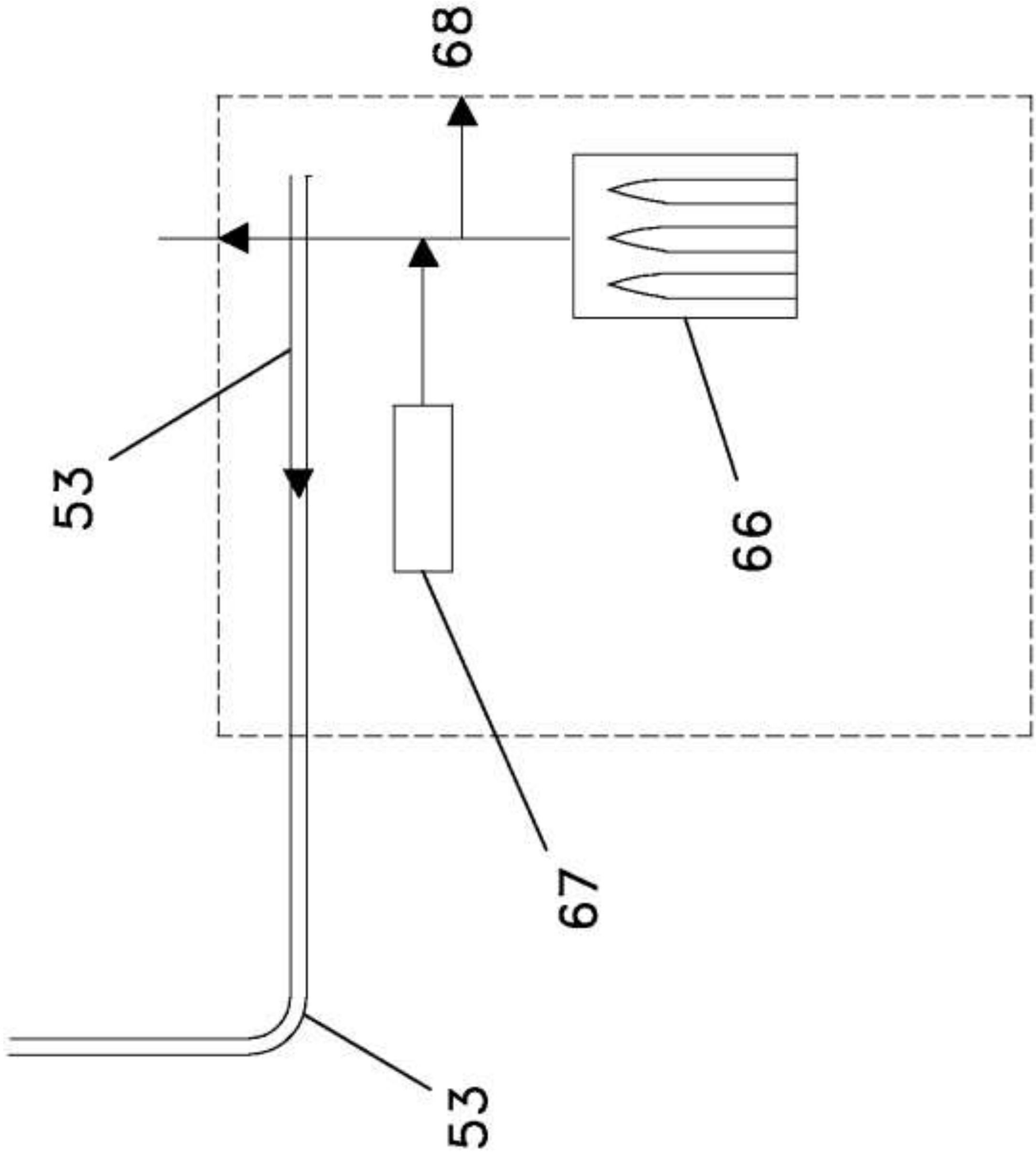


Figure 3.3.6.18. Conceptual view of an auxiliary-treatment area of a solid carbonaceous materials gasifier system in one embodiment

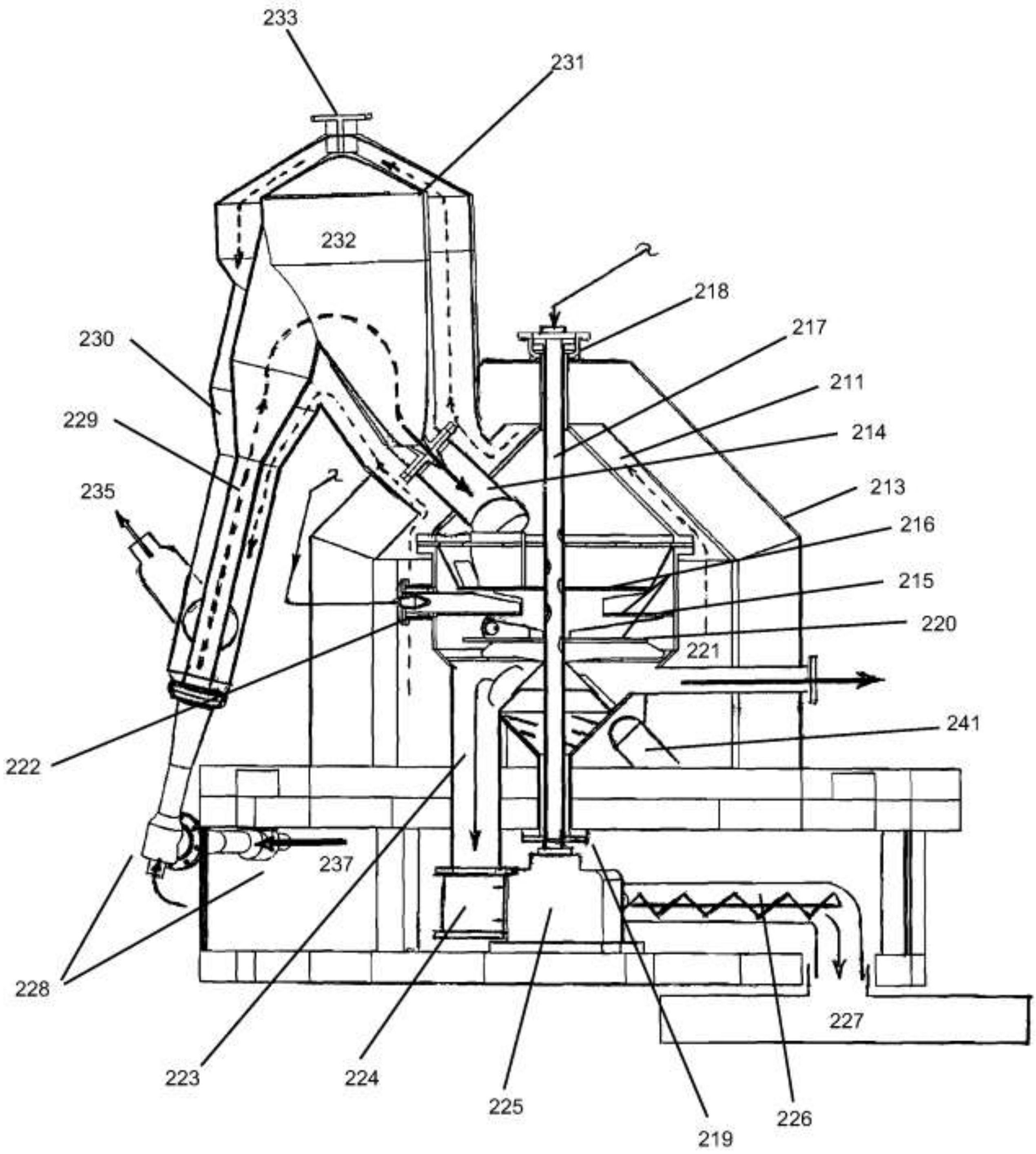


Figure 3.3.6.19. Cross section view of a "pod" embodiment of the present technology

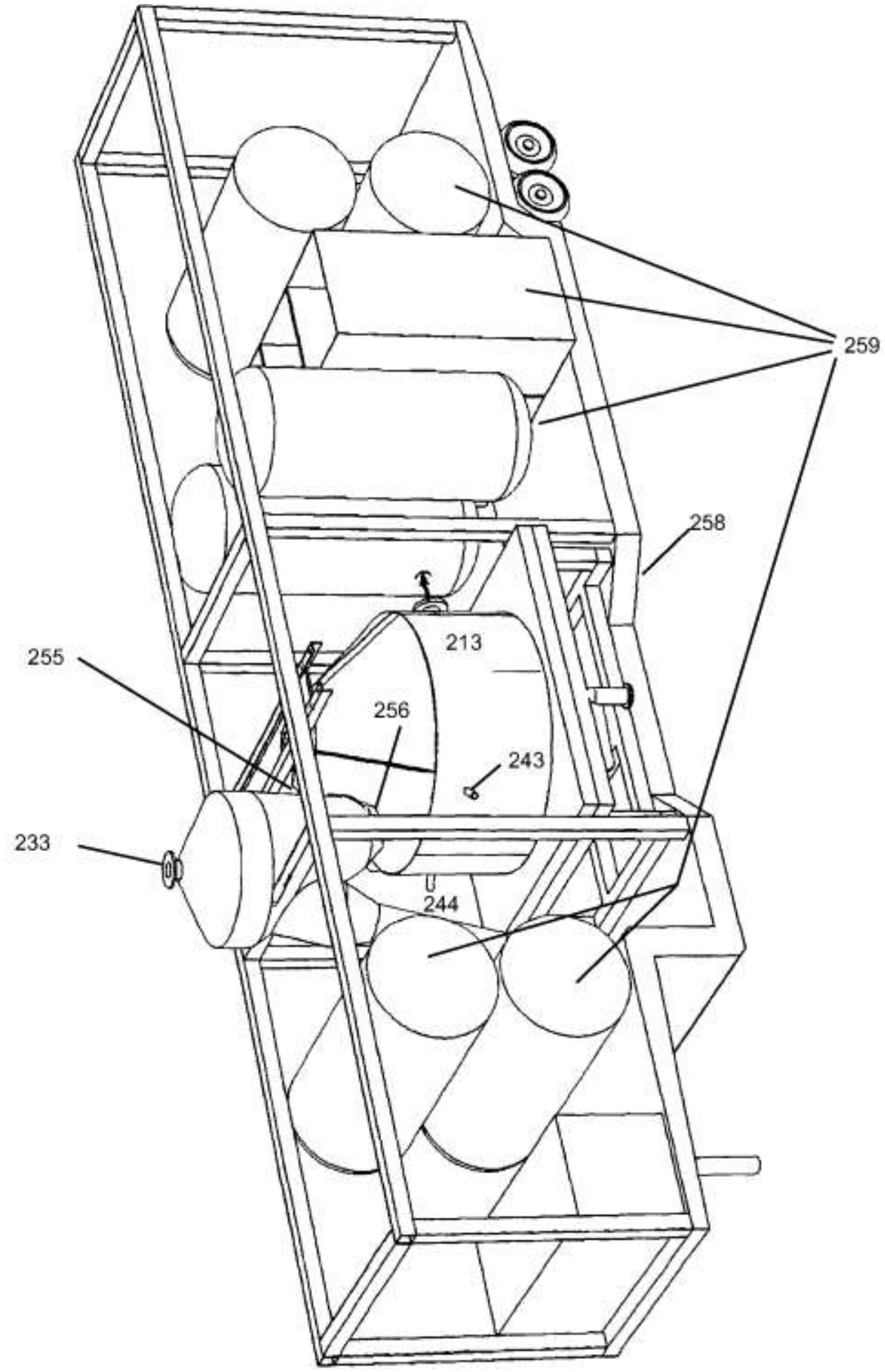


Figure 3.3.6.20. Perspective view of a trailerable embodiment of the present technology

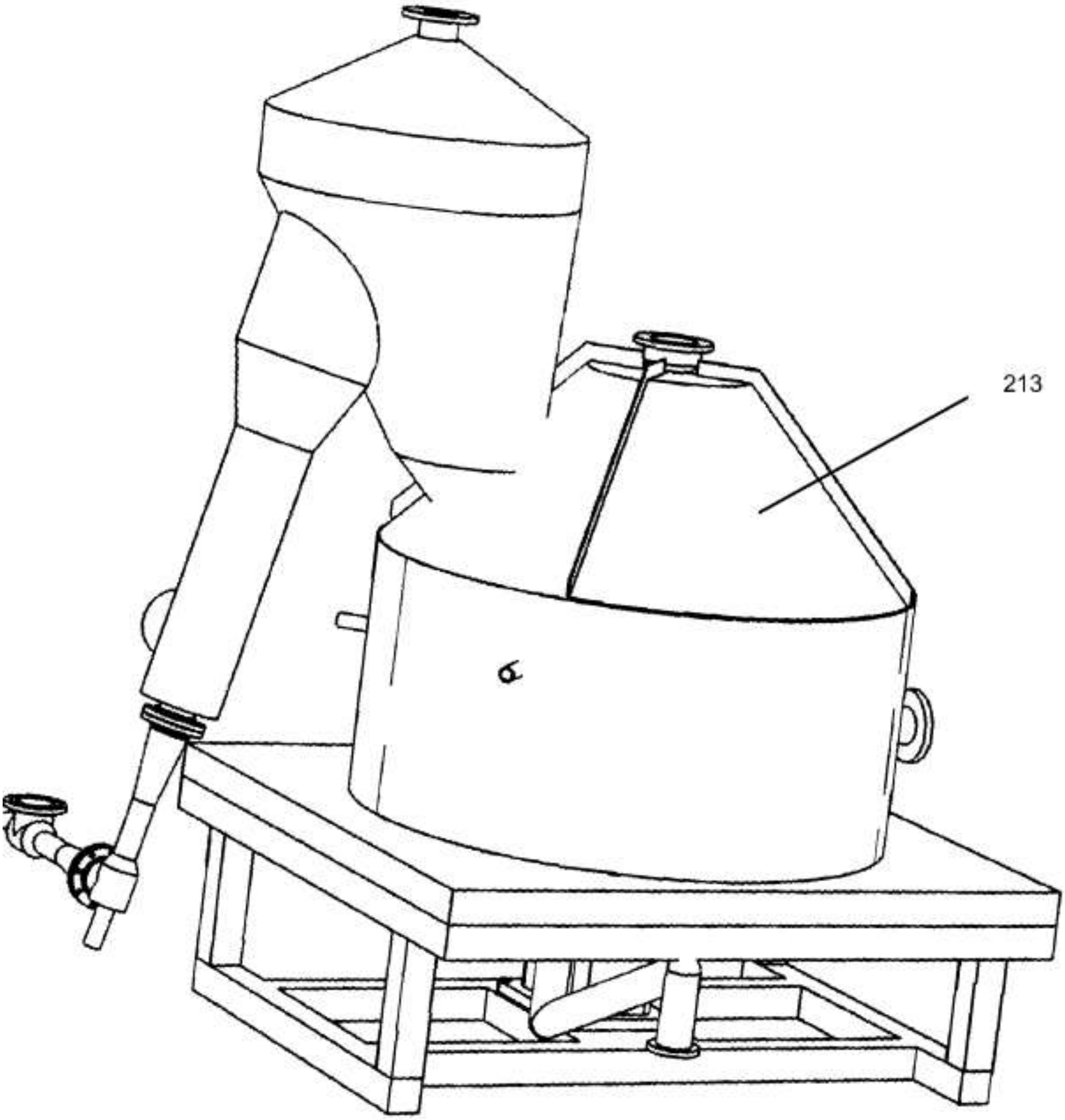


Figure 3.3.6.21. Perspective view of a portion of a "pod" embodiment of the present technology

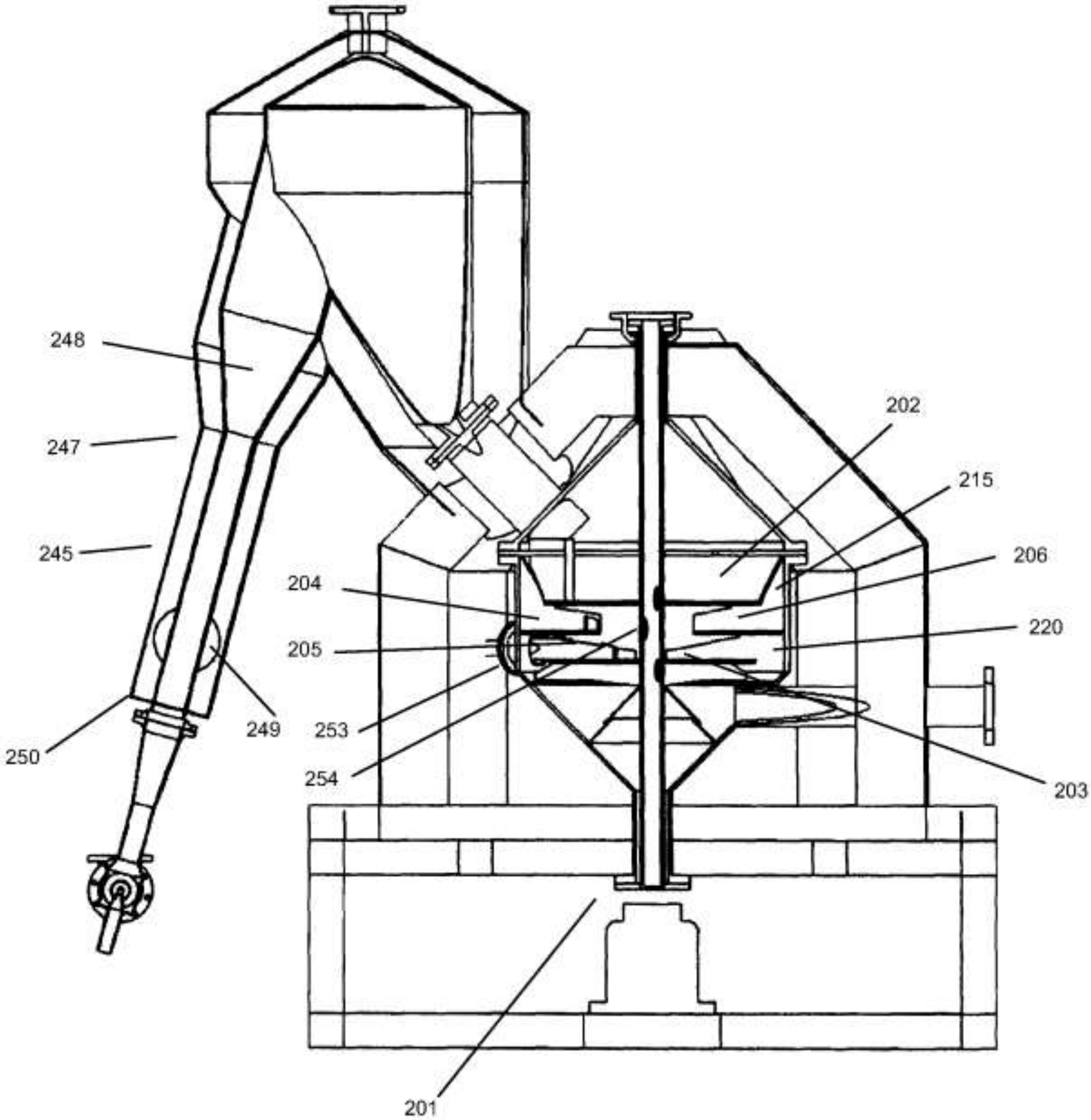


Figure 3.3.6.22. Cross-section view of a reactor portion of a "pod" embodiment of the present technology

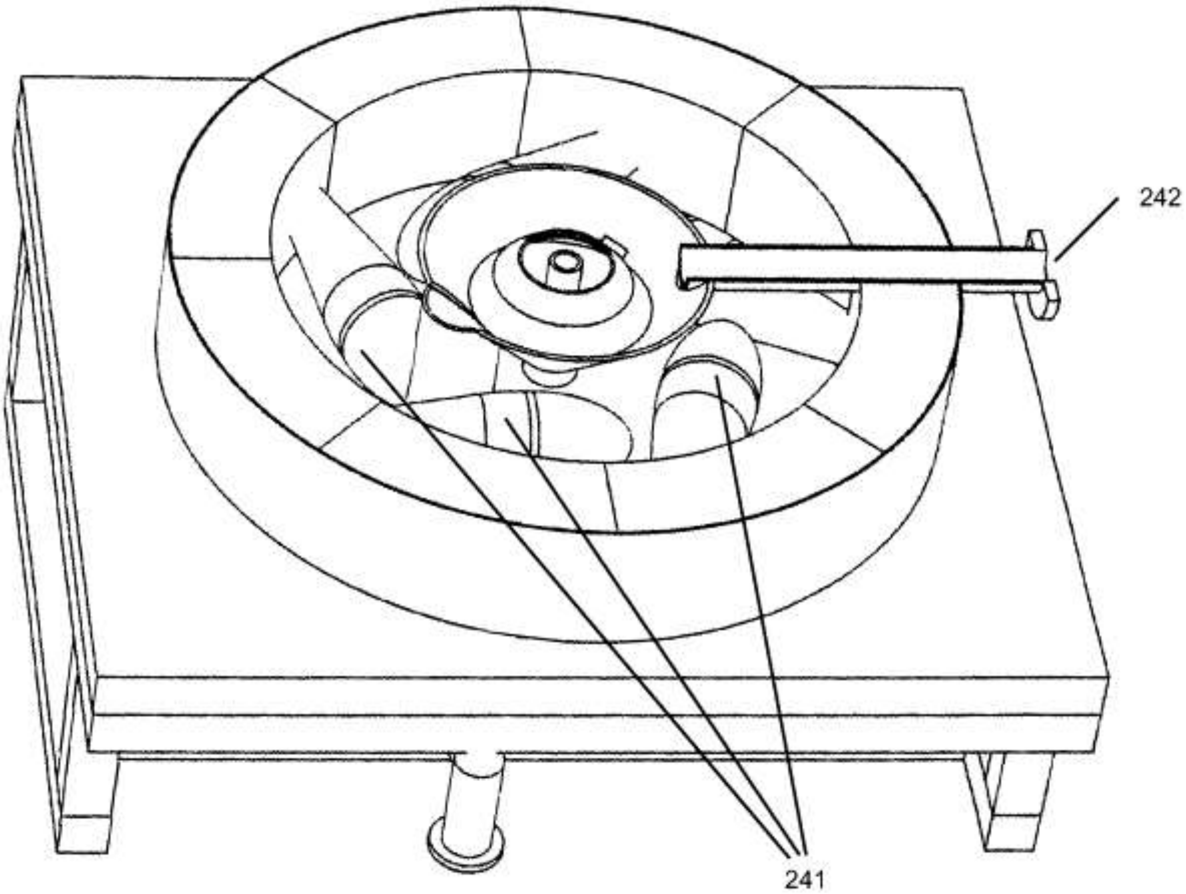


Figure 3.3.6.23. Perspective view of a lower portion of a "pod" embodiment of the present TCG

THE DRAWINGS

Figure 3.3.6.1. The TCG Unit isometric view
Figure 3.3.6.2. Conceptual view of a gasifier process flow path with delimited functional areas in one embodiment.
Figure 3.3.6.3. Conceptual view of a gasifier process flow path without delimited functional areas in one embodiment.
Figure 3.3.6.4. Front perspective view of a solid carbonaceous materials gasifier system in one embodiment.
Figure 3.3.6.5. Rear perspective view of a solid carbonaceous materials gasifier system in one embodiment.
Figure 3.3.6.6. Sectional cutaway view of a multiple coil carbonaceous reformation vessel in one embodiment.
Figure 3.3.6.7. Perspective view of a multiple coil carbonaceous reformation vessel in one embodiment.
Figure 3.3.6.8. Perspective view of a multiple coil carbonaceous reformation vessel in one embodiment.
Figure 3.3.6.9. Side cutaway view of a venturi injector in one embodiment.
Figure 3.3.6.10. Cross section view of a venturi injector in one embodiment.
Figure 3.3.6.11. Diagrammatic view of a negatively electrostatically enhanced water species generation unit in one embodiment.
Figure 3.3.6.12. Diagrammatic view of a select product gas components scrubber in one embodiment.
Figure 3.3.6.13. Conceptual view of a pretreatment area of a solid carbonaceous materials gasifier system in one embodiment.
Figure 3.3.6.14. Conceptual view of a pyrolytic decomposition area of a solid carbonaceous materials gasifier system in one embodiment.
Figure 3.3.6.15. Conceptual view of a carbonaceous materials reformation area of a solid carbonaceous materials gasifier system in one embodiment.
Figure 3.3.6.16. Conceptual view of an ash removal area of a solid carbonaceous materials gasifier system in one embodiment.
Figure 3.3.6.17. Conceptual view of a scrubber area of a solid carbonaceous materials gasifier system in one embodiment.
Figure 3.3.6.18. Conceptual view of an auxiliary-treatment area of a solid carbonaceous materials gasifier system in one embodiment.
Figure 3.3.6.19. Cross section view of a "pod" embodiment of the present technology.
Figure 3.3.6.20. Perspective view of a trailerable embodiment of the present technology.
Figure 3.3.6.21. Perspective view of a portion of a "pod" embodiment of the present technology.
Figure 3.3.6.22. Cross-section view of a reactor portion of a "pod" embodiment of the present technology.
Figure 3.3.6.23. Perspective view of a lower portion of a "pod" embodiment of the present TCG

The present TCG technology includes a variety of aspects, which may be combined in different ways. The following descriptions are provided to list elements and describe some of the embodiments of the present TCG technology. These elements are listed with initial embodiments, however it should be understood that they may be combined in any manner and in any number to create additional embodiments. The variously described examples and preferred embodiments should not be construed to limit the present TCG technology to only the explicitly described systems, techniques, and applications. Further, this description should be understood to support and encompass descriptions and claims of all the various embodiments, systems, techniques, methods, devices, and applications with any number of the disclosed elements, with each element alone, and also with any and all various permutations and combinations of all elements in this or any subsequent application.

A solid carbonaceous materials gasifier system in various embodiments perhaps may be configured to modular sections. Embodiments may involve a system having functional areas (Figures 3.3.6.2.; 3.3.6.5.) perhaps such as:

-
    - a pretreatment area (**74**), perhaps to include bulk handling of input feedstock solid carbonaceous material, displacement at least some oxygen content from the feedstock solid carbonaceous material, and perhaps other preparation handling for subsequent processing of the feedstock solid carbonaceous material;
    - a pyrolytic decomposition area (**75**), as an initial gasification zone perhaps to include varying a retention time of feedstock solid carbonaceous material in a temperature varied environment, as in perhaps a pyrolysis chamber;
    - a carbonaceous materials reformation area (**77**), as another gasification zone perhaps to include carbonaceous reformation of pyrolytically decomposed carbonaceous materials, such as in a multiple coil reformation vessel or perhaps even in a helically nested configuration of reformation coils in a multiple coil reformation vessel;
    - an ash removal area (**78**), perhaps to include ash removal such as by downdraft cool-down and pulse-evacuation containment;
    - a scrubber area (**79**), perhaps to include removal of contaminants from a generated select product gas, such as by combined chill and spray of a negative electrostatically enhanced water species and even polarized media polish filtration;

- an auxiliary treatment area (**76**), perhaps to include select product gas preparation for gasifier embodiment combustion heating, such as with oxygen enrichment and reduction of nitrogen content, perhaps utilizing an air separation unit.

Of course, these areas merely exemplify one possible modular configuration for a solid carbonaceous materials gasifier system to illustrate the concept of modularity in perhaps one embodiment, and should not be regarded as limiting the possible modular configurations of such a gasifier system, the distribution of various gasification functions within modular sections of a gasifier system, or indeed even to limit the TCG technology to modular embodiments, consistent with the TCG principles discussed herein.

The TCG technology may involve processes for carbon conversion that perhaps may be categorized as gasification. Carbon conversion may involve the conversion of carbon content in a feedstock solids carbonaceous material, perhaps including a majority or possibly even substantially all of such carbon content, into select product gas components or even a select product gas. In embodiments, such processes may include thermal processes, perhaps including elevated temperatures in reducing conditions or with little or no free oxygen present, to produce a select product gas, such as a permanent and combustible synthesis gas. Such a select product gas often may include predominantly CO and H_2, with some CH_4 volume output, though the process control parameters may allow significant control over the make-up of a produced select product gas in particular applications. The process also may involve minor by-products of various types, perhaps such as char ash, condensable inorganics and organics, or trace hydrocarbons.

In some embodiments, a solid carbonaceous materials gasifier system may be initially started with an auxiliary fuel, such as an external source of propane, as may be supplied to a gasifier system process enclosure, for example such as to a box furnace enclosure (**26**) (FIGURE 3.3.6.2. ; 3.3.6.3.; 3.3.6.**14**) at a combustive burner (**14**) (FIGURE 3.3.6.2. ; 3.3.6.3.). This may be used, for example, perhaps until the reformation coils (**19**) (FIGURE 3.3.6.2. ; 3.3.6.**3**; 3.3.6.4; 3.3.6.5) of a multiple coil reformation vessel reach a suitable operational temperature, for example perhaps about 1600° F. to 1800° F. In some embodiments, this may take approximately 24 hours. At this point some embodiments may be capable of producing a select product gas whereby a fractional portion may be returned to the combustive burner to sustain combustion and maintain a desired process operational temperature. In this manner, the system perhaps may become self-sustaining and auxiliary fuel support may be shut off, perhaps with input delivery of feedstock solids carbonaceous materials for processing to be started or continued into the gasifier system.

A solid carbonaceous materials gasifier system in various embodiments may include a gasifier process flow path originating at a feedstock solids carbonaceous materials input and routed through the solid carbonaceous materials process gasifier system. A process flow path may provide a path by which solid carbonaceous materials input into the gasifier system may be routed to various processing areas of the gasifier system, perhaps ultimately for output of a select product gas at a terminus of the gasifier process flow path. Moreover, such a gasifier system perhaps may be characterized as capable of receiving solid carbonaceous materials at the input of the gasifier process flow path, which carbonaceous materials may be solid in nature, perhaps as distinguished from fluidized bed and updraft or downdraft gasifiers which often utilize liquid feedstocks, slurried feedstocks, or other feedstock having substantially non-solidified compositions. For example, such solid carbonaceous material in some embodiments may include solid carbonaceous particles milled to a size appropriate for throughput through the gasifier system's process flow path, such as perhaps to less than about 2 cubic inches in particle size. Moreover, the dynamic adjustability of various process control parameters may permit the gasifier system to accept a great variety of solid carbonaceous materials for input, with the dynamic adjustability of the gasifier system compensating for variations in the input make-up to permit consistent output of desired select product gas. For example, solid carbonaceous materials suitable for input may include, but of course are not limited to, varied carbon content, varied oxygen content, varied hydrogen content, varied water content, varied particle sizes, varied hardness, varied density, and the like, perhaps such as including varied wood waste content, varied municipal solid waste content, varied garbage content, varied sewage solids content, varied manure content, varied biomass content, varied rubber content, varied coal content, varied petroleum coke content, varied food waste content, varied agricultural waste content, and the like.

A solid carbonaceous materials gasifier system in various embodiments may be configured to process feedstock solids carbonaceous materials in a variety of manners. Processing may involve perhaps simply treating a carbonaceous material in some capacity. For example, processing in various embodiments may include pretreating a feedstock solids carbonaceous material within a pretreatment area, pyrolytically decomposing in a pyrolysis chamber, carbonaceously reforming in a multiple coil carbonaceous reformation vessel, preliminarily carbonaceously reforming in a preliminary carbonaceous reformation coil, secondarily carbonaceously reforming in a secondary carbonaceous reformation coil, tertiarily carbonaceously reforming in a tertiary carbonaceous reformation coil, vaporizing a carbonaceous material including perhaps vaporizing hydrocarbons or perhaps vaporizing select product gas components, processing with a negatively electrostatically enhanced water species, processing with negatively electrostatically enhanced steam, processing with a flue gas, processing with a pressurized flue gas, processing with a preheated flue gas, processing with a scrubber recycled tar, processing with a scrubber recycled phenol, processing with a scrubber recycled solid, processing with a select product gas, processing with a wet select product gas, processing with a dry select product gas, processing with a recycled select product gas, or other appropriate steps of treating carbonaceous materials appropriate for gasification processes. Moreover, embodiments may include multiple processing steps, which may be related as steps of initial processing, subsequent processing, and the like. Of course, such steps of processing may be accomplished by an appropriate processor, for example a pretreatment area processor, a pyrolysis chamber, a multiple coil carbonaceous reformation vessel, a preliminary carbonaceous reformation coil of a multiple coil carbonaceous reformation vessel, a secondary carbonaceous reformation coil of a multiple coil carbonaceous reformation vessel, a tertiary carbonaceous reformation coil of a multiple coil carbonaceous reformation vessel, and the like.

A feedstock solids carbonaceous materials input in some embodiments may include a walking floor or other raw feedstock holding bin (**1**) (FIGURE 3.3.6.2. ; 3.3.6.3; 3.3.6.**13.**), perhaps with a continuous volume of input feedstock solids carbonaceous material that has been previously milled or shredded to an input particle size not to exceed as desired. Further, in embodiments, an inventory storage volume may be selected, for example perhaps a five day inventory storage volume, to ensure a consistent supply of feedstock carbonaceous materials for input. In embodiments, gasifier system exhaust flue gas (**9**) (FIGURE 3.3.6.2. ; 3.3.6.3; 3.3.6.**13**), produced for example perhaps by combustive burners, may be directed to a compressor, such as a high temperature delivery compressor (**8**) (FIGURE 3.3.6.2. ; 3.3.6.3; 3.3.6.**13**), whereby the flue gas temperature may be reduced from a high temperature, perhaps approximately 700° F., to a lower temperature. This may occur via an in-line heat exchanger or the like, not shown. In embodiments, temperature reduction may be down to about 300° F. Further, the compressor may also pressure regulate small volume and may also intermittently inject hot flue gas into a holding bin to additionally dry out moisture within the feedstock solids carbonaceous material, if required. A suitable feedstock delivery system, such as a variable speed horizontal metering screw (not shown), may be used to deliver a controlled rate volume feed of feedstock solids carbonaceous material to a variable speed inclined conveyor (**2**) (FIGURE 3.3.6.2. ; 3.3.6.3; 3.3.6.4; 3.3.6.5; 3.3.6.**13**) or the like.

A pressure system in some embodiments may be joined to a gasifier process flow path to pressurize the feedstock solids carbonaceous material as appropriate, for example perhaps by configuring the variable speed inclined conveyor to be sealed, perhaps such as in a pressure-tight unit cylinder. Such a pressure system also may include a flue gas delivery compressor to perhaps also pressure regulate a small but continuous volume delivery of hot flue gas into a conveyor unit, perhaps sealed cylinder, with perhaps an about 40 psi pressure being maintained throughout the conveyor feed cylinder. This may be fed into an inlet feed plenum assembly (**6**) (FIGURE 3.3.6.2. ; 3.3.6.3; 3.3.6.4; 3.3.6.**13**). The pressure system further may involve a conveyor unit cylinder pressure (perhaps flanged) sealed to an inlet plenum assembly, and the conveyor drive motor perhaps may be mounted outside the conveyor pressure unit cylinder. Further, a motor drive shaft may also be pressure sealed as part of a pressure system perhaps through the wall of a conveyor housing cylinder. Flue gas may be further compressed and pressure regulated and injected at the top of an inlet, perhaps airtight, plenum. This may occur such as at injection position (**3**) (FIGURE 3.3.6.2. ; 3.3.6.3; 3.3.6.**13**). Location and amount may be selected to ensure that a desired continuous pre-heat temperature, such as approximately 300° F. and 40 psi positive pressure, is maintained in the inlet plenum chamber.

In addition to the benefit of hot flue gas drying out excess feedstock moisture, hot flue gas may be used to displace and starve excess air out of the input feedstock materials. Such use of hot flue gas may be employed as part of an oxygen displacement system, which may represent a meaningful process control variable to limit air content, including perhaps oxygen levels, in the inlet plenum feed assembly. Such an oxygen displacement system may be employed gravimetrically, for example perhaps by injecting flue gas at the bottom of an incline, perhaps via an incline base input, through which a feedstock solids carbonaceous material may be moved and releasing oxygen content from the top of the incline, for example perhaps via an incline apex output. In some process configurations hot product gas may be substitute added, instead of utilizing flue gas, to achieve the same drying and displacement benefits and add more carbon element return. In some embodiments, such an incline may be a variable speed inclined conveyor (**2**) (FIGURE 3.3.6.2. ; 3.3.6.3; 3.3.6. 3.3.6.4; 3.3.6.5; 3.3.6.**13**) or the like. Gravimetric displacement may occur as the injected flue gas rises gravimetrically through the incline, perhaps physically displacing air content and oxygen content along the way. Release of the displaced air or oxygen content may be affected through use of a suitable port, valve, outlet, or the like, at the top of the incline. Moreover, while injected flue gas may suffice for oxygen displacement, it may be appreciated that any suitable substance may be injected consistent with the gravimetric principles herein described, including for example using flue gas, using pressurized flue gas, using preheated flue gas, using recycled flue gas, using select product gas, using wet select product gas, using dry select product gas, using recycled select product gas, and the like. Of course, temperature and pressure characteristics of these injected substances may be selected as appropriate to achieve oxygen displacement, including for example pressurizing to at least 40 psi and preheating to at least 300 degrees Fahrenheit.

Further, the flue gas may consist of large concentrations of CO which may assist in the conversion of volatile gases to release free carbon. Periodic small volumes of plenum flue gas may also be auto-vented as a safety relief perhaps such as through an exhaust filter (**5**) (FIGURE 3.3.6.2. ; 3.3.6.3; 3.3.6.**13**) and a pressure relief/control valve (**71**) (FIGURE 3.3.6.2. ; 3.3.6.3; 3.3.6.**14**) which may be configured at the top of a plenum exhaust bleed outlet (**4**) (FIGURE 3.3.6.2. ; 3.3.6.3; 3.3.6.**13**). This may also be directed to an external flare system.

A gasifier flow path may be routed through one or more suitable airlock components to maintain pressure in a pressure system, for example a rotary type airlock material feed-through valve (not shown). Such airlock components may be configured to ensure that a desired pressure, for example perhaps a constant 40 psi pressure, can be held among the pressurized components of the system, for example perhaps at the plenum delivery system. Such maintained pressure also may prevent the back-feed of materials from subsequent processing areas of the gasifier system. In addition, by maintaining a perhaps 40 psi or so positive plenum pressure, the downward injection of feedstock solids carbonaceous materials into subsequent processing areas may be pressure assisted. In embodiments, the feedstock solids carbonaceous materials may transfer by gravity through a suitable airlock component, for example perhaps through wide throat airlock valves. In this arrangement, one valve may sequence into an open position while the other valve remains in a closed position, thereby allowing a volume of feedstock material to be retained in a holding chamber between the two valves. In this, or other manners, when the lower valve opens, the feedstock material may drop into a connecting conduit, perhaps through a box furnace enclosure (**26**) (FIGURE 3.3.6.2. ; 3.3.6.3) and into a subsequent processing areas of the gasifier system (FIGURE 3.3.6.2. ; 3.3.6.3).

Of course, a pressure system through which a gasifier process flow path is routed should not be construed as limited merely to the foregoing examples described herein. Rather, a pressure system perhaps simply may involve maintaining one or more areas within a solid carbonaceous materials gasifier system at a different pressure than that outside of the solid carbonaceous materials gasifier system. Such pressure maintenance may be accomplished in any suitable manner consistent with the principles described herein, for example perhaps through the use of an airlock, a double airlock, an injector that injects a pressurized substance such as a pressurized flue gas or pressurized select product gas, or perhaps even an inductor configured to maintain a pressure. Moreover, a pressure system may be applied to any gasifier system enclosures for which pressurization may be required, such as perhaps a pretreatment environment enclosure, a pyrolysis chamber enclosure, a multiple coil carbonaceous reformation vessel enclosure, any or all parts of a gasifier process flow path routed through a solid carbonaceous materials gasifier system, and the like. In some embodiments, a pressure system may be sealed, for example as to prevent communication between the pressurized environment and an unpressurized environment or perhaps to seal a feedstock solids carbonaceous material within the solid carbonaceous materials gasifier system.

Various embodiments may involve joining a heater system to a gasifier process flow path. Joining may be understood to involve perhaps simply brining two elements into some degree of mutual relation, for example, a heater system joined to a gasifier process flow path simply may permit the heater system to heat at least some of the gasifier process flow path. Heating in this manner may be effected in any suitable manner, for example perhaps by a combustive burner, an electric heater or the like. In various embodiments, a heater system may be configured to supply heat appropriate for a particular processing stage. In this manner, a heater system in various embodiments may include pyrolysis temperature heater system, a carbonaceous reformation temperature heater system, a variable temperature zone heater system, a heater system configured to establish a temperature from 125° F. to 135° F., a heater system configured to establish a temperature from 135° F. to 300° F., a heater system configured to establish a temperature from 300° F. to 1,000° F., a heater system configured to establish a temperature from 1,000° F. to 1,640° F., and a heater system configured to establish a temperature from 1,640° F. to 1,850° F.

In various embodiments, a gasifier process flow path may be routed through a temperature varied environment. A temperature varied environment may include a contiguous portion of a gasifier process flow path heated to varied temperatures, as for example by a variable temperature zone heater system. Some embodiments may use a gravity drop flow of feedstock material such as from the bottom of airlock valve (**7**) (FIGURE 3.3.6.2. ; 3.3.6.3; 3.3.6.4; 3.3.6.5; 3.3.6.**13**) and through the wall of a box furnace enclosure (**26**) (FIGURE 3.3.6.2. ; 3.3.6.3; 3.3.6.**14**). This perhaps may be arranged directly into a temperature varied environment, perhaps where one or more dynamically adjustable process flow parameters may be utilized to process the feedstock solids carbonaceous material. Overall operational temperature such as within a temperature varied environment may be regulated so that an inlet conduit entering from a previous processing area may provide incoming feedstock solids carbonaceous materials at an elevated temperature, perhaps such as at approximately 250° F. to 300° F., and perhaps as dependant upon any of various suitable dynamically adjustable process determinative parameters, such as the volume of a negatively electrostatically enhanced water species or the temperature of an injected flue gas. A temperature gradient may be established within the temperature varied environment perhaps from about 300° F. at an input area and reaching about 900° F. to 1000° F. toward an output area. Of course, any suitable heater system capable of variable heat output may be used to achieve such variable temperature zones. In some embodiments, for example, a series of electric heaters, combustive burners, or the like may be configured to produce a temperature varied environment.

A temperature varied environment in various embodiments may include a liquefaction zone. A liquefaction zone may be a temperature zone of a varied temperature environment in which feedstock solids carbonaceous materials may tend to liquefy, for example such as by being heated to their liquefaction temperature. Embodiments may include a plurality of movement guides in a temperature varied environment, perhaps temperature variable movement guides capable of being heated to varied temperatures as a result of being moved through said temperature varied environment, perhaps including trans-liquefaction movement guides disposed through the temperature varied environment that may engage a feedstock solids carbonaceous material for transport through the temperature varied environment and liquefaction zone. Such movement through the liquefaction zone may include receiving a feedstock solids carbonaceous material at a pre-liquefaction temperature zone of the temperature varied environment, which may perhaps be a cooler temperature than required to liquefy the feedstock solids carbonaceous material, moving the feedstock solids carbonaceous material through the liquefaction zone, at which point the feedstock solids carbonaceous material may liquefy, and moving the liquefied feedstock solids carbonaceous material into a post-liquefaction temperature zone, which may perhaps be a hotter temperature than the liquefaction temperature of the feedstock solids carbonaceous material.

In some embodiments, a plurality of trans-liquefaction movement guides may be joined to a temperature varied cyclical return. Such a temperature varied cyclical return may permit the trans-liquefaction movement guides to move through the temperature varied environment on a cyclical path. A trans-liquefaction movement guide undergoing such cyclical motion, for example, may begin within one temperature zone of the temperature varied environment, move through one or more other temperature zones of the temperature varied environment, and be returned to its original starting position within the first temperature zone of the temperature varied environment, where the cycle may be repeated. Of course, any of a variety of appropriate devices may accomplish such cycling. In some embodiments, for example, a temperature varied cyclical return may include an endless loop conveyor system, perhaps such as a track feeder (**10**) (FIGURE 3.3.6.2. ; 3.3.6.3; 3.3.6.4; 3.3.6.5; 3.3.6.**14**). Embodiments also may include varying the speed at which a temperature varied cyclical return is operated, perhaps to vary a retention time at which feedstock solid carbonaceous materials engaged by a plurality of trans-liquefaction movement guides may be retained within a temperature varied environment. In this manner, a track feeder (**10**) (FIGURE 3.3.6.2. ; 3.3.6.3; 3.3.6.4; 3.3.6.5; 3.3.6.**14**) may be provided with a variable return cycle.

In some embodiments, movement guides may be translatable movement guides. Configuring movement guides to be translatable may involve moving a feedstock solids carbonaceous material engaged to the movement guide by physically translating the movement guide itself. For example, where movement guides in embodiments may be joined to a temperature varied cyclical return, the cyclical motion of the return may act to physically translate the position of the movement guides, as perhaps through the cyclical motion of the return. Moreover, such a translatable nature of movement guides may be compared to non-translating motion systems, for example perhaps rotating screw systems, wherein the position of the screw itself may not translate and motion may be imparted simply by the rotation of the screw. In some embodiments, the translatable nature of the movement guides may assist in preventing binding of the movement guides by liquefied feedstock solids carbonaceous materials, perhaps in as much as translating the position of the movement guides may serve to translationally push liquefying feedstock into a higher temperature zone, and even possibly by cyclically varying the temperature of the movement guides themselves to avoid holding them at a liquefaction temperature.
Cycling movement guides in a temperature varied environment further may include automatically periodically clearing the movement guides of feedstock solids carbonaceous materials that may have liquefied when moved through a liquefaction zone. For example,

cycling may involve continuously varying the temperature of the movement guides, perhaps including cyclically raising and lowering the temperature of the movement guides as they are cycled through a varied temperature regime. Such temperature change of the movement guides may be alternately through a pre-liquefaction temperature and a post-liquefaction temperature, avoiding holding of the movement guides at a liquefaction temperature, and in this manner it may be seen that liquefied feedstock solids carbonaceous material to which individual movement guides are engaged may be vaporized as the movement guides cycle through their post-liquefaction temperatures. Accordingly, the movement guides may be automatically periodically cleared as a result of such cycling, and binding of the movement guides may be avoided in as much as the liquefied dry solids carbonaceous feedstock may be systematically vaporized. In this manner, the movement guides may be considered as configured to avoid a sustained liquefaction temperature, configured for cyclical elevation and reduction in temperature, configured for cyclical liquefaction and vaporization of feedstock solids carbonaceous material, and may even be considered to be binding resistant movement guides.

A track feeder and plurality of trans-liquefaction movement guides in some embodiments may be configured to include a track-heat-scraper plate. For example, in some embodiments, along the bottom longitudinal centerline underside of a track heat-scraper plate (not shown) may be located a parallel row of progressive electric heaters (**11**) (FIGURE 3.3.6.2. ; 3.3.6.3; 3.3.6.**14**) that may even sequentially control a temperature gradient. Similarly, in some embodiments a select product gas burner manifold may be used as a heating source and perhaps may be located external and adjacent to the track feeder embodiment. A scraper wear plate may be periodically replaced as required and may even be fabricated and cast from hardened high temperature metallic material. A counter-clockwise rotation of a feeder track may be used to move feedstock solids carbonaceous material to the bottom underside of the track feeder.

Moreover, in some embodiments, such varied temperatures may include pyrolysis temperatures suitable to pyrolytically decompose at least some of a feedstock solids carbonaceous material routed through the temperature varied environment along a gasifier process flow path. Pyrolysis may involve heating the feedstock solids carbonaceous material in the absence of reactively significant amounts of oxygen to induce decomposition of the feedstock solids carbonaceous material, as perhaps by consequential thermal reactions, chemical reactions, and volatilization reactions. The absence of such reactively significant amounts of oxygen perhaps need not require the total absence of oxygen (although this condition certainly may be included), but rather perhaps may include merely an amount of oxygen that produces merely insubstantial or perhaps even nonexistent combustion when said feedstock solids carbonaceous material is subjected to the temperature varied environment. In various embodiments, pyrolytically decomposing may involve vaporizing a carbonaceous material, for example perhaps vaporizing hydrocarbons or perhaps vaporizing select product gas components. Further, in some embodiments, portions of a temperature varied environment in which pyrolytic decomposition may occur accordingly may be considered to include a pyrolysis chamber.

In some embodiments, pyrolytically decomposing a feedstock solids carbonaceous material in a temperature varied environment may include dominatively pyrolytically decomposing the feedstock solids carbonaceous material. Such dominative pyrolysis may involve pyrolyzing to a high degree, perhaps by subjecting the feedstock solids carbonaceous material to prolonged pyrolyzing conditions. For example, embodiments may include retaining a feedstock solids carbonaceous material within a pyrolysis chamber of a temperature varied environment for at least 2 minutes, at least 3 minutes, at least 4 minutes, at least 5 minutes, at least 6 minutes, at least 7 minutes, at least 8 minutes, at least 9 minutes, at least 10 minutes, at least 11 minutes, at least 12 minutes, at least 13 minutes, at least 14 minutes, at least 15 minutes, at least 16 minutes, at least 17 minutes, at least 18 minutes, at least 19 minutes, or at least 20 minutes, for example perhaps by varying the speed of a temperature varied cyclical return and a plurality of movement guides joined to the temperature varied cyclical return. Such retention times perhaps may be substantially longer than conventional pyrolysis times, and perhaps may be achievable by minimizing or perhaps even eliminating binding caused by liquefaction that perhaps may plague conventional pyrolysis systems.

Moreover, pyrolysis or even dominative pyrolysis may be facilitated in various embodiments by maximizing the surface area of a track feeder to increase the surface area contact of a feedstock solids carbonaceous material to the pyrolysis conditions of a pyrolysis chamber. For example, embodiments may include maximizing the surface area of a track feeder (**10**) (FIGURE 3.3.6.2. ; 3.3.6.3; 3.3.6.4; 3.3.6.5; 3.3.6.**14**), for example including perhaps dimensioning the track feeder to at least 24 inches in width, to at least 30 inches in width, to at least 36 inches in width, to at least 42 inches in width, to at least 48 inches in width, to at least 54 inches in width, to at least 60 inches in width, to at least 66 inches in width, to at least 72 inches in width, to at least 3 feet in length, to at least 6 feet in length, to at least 9 feet in length, to at least 12 feet in length, to at least 15 feet in length, to at least 18 feet in length, and to at least 21 feet in length. Such dimensions may be perhaps at ten to twenty times greater surface area exposure than a conventional 3 or 4 stage auger feed pyrolysis system design, and may be without the binding or plugging probabilities mentioned earlier.

A track feeder in various embodiments may represent an integrated process control module, perhaps with sequenced computer automation. Process flow embodiments may be monitored to provide an adjustable time period to extend or shorten pyrolytic decomposition times for throughput feedstock solids carbonaceous material to undergo perhaps complete reaction contact with heat, flue gas CO, negatively electrostatically enhanced water species, and the like. A track feeder system design in various embodiments may be sized to automatically process perhaps about 50 tons/day and up to 500 tons/day of input feedstock solids carbonaceous materials. Of course, multiple track feeders, perhaps routed through multiple temperature varied environments perhaps including pyrolysis chambers, may be utilized in some embodiments to increase total feedstock solids carbonaceous materials throughput. Track feeder maximized surface areas, adjustable temperatures, progressive time controls, and track speed control variables may be included in embodiments such as to allow extended pyrolysis time or the like and to provide a capability to near completely pyrolytically decompose the feedstock solid carbonaceous material, including perhaps tars and phenolic chemistry fractions. In some embodiments, small volume additions of calcined dolomite also may be added, for example at a pretreatment area, such to speed up and catalyze the sulfurs or tars and phenols initial cracking process that may occur in the pyrolysis chamber. Track feeder operational up-time may even approach 100%, except perhaps for short 2-3 day periods of monthly preventive maintenance. The components of a track feeder, such as chains, sprockets, and drive shafts, perhaps may be manufactured from high temperature Inconel® alloy metal stock or the like, or other alternate and appropriate metallic materials, and in addition, components such as track flights and bottom track scraper wear and heater plates (not shown) may be custom cast with high temperature metallurgy or the like. Track feeder drive bearings may be standard nuclear industry high temperature sealed units, perhaps with an outboard variable speed motor drive unit that may provide a track rotational movement selection of one to five revolutions per minute. An additional auto-vent safety-relief pressure control and relief valve (**71**) (FIGURE 3.3.6.2. ; 3.3.6.3; 3.3.6.**14**; 3.3.6.**15**) may be installed and perhaps even centered through the top of a box furnace enclosure (**26**) (FIGURE 3.3.6.2. ; 3.3.6.3; 3.3.6.**14**). Of course, the use of a temperature varied cyclical return as described herein may preclude the need for any type of auger screw or perhaps even any screw type movement system through a pyrolysis chamber of a temperature varied environment as described herein.

Various embodiments further may include a magnetic materials removal system (**12**) (FIGURE 3.3.6.2. ; 3.3.6.3) through which a gasifier process flow path is routed, perhaps to magnetically isolate at least one constituent component of a feedstock solids carbonaceous material. Such a magnetic materials removal system may use a magnet to magnetically attract metallic constituent components of a feedstock solids carbonaceous material. Where a nonmetallic constituent component is desired to be removed, embodiments perhaps may still achieve removal of such nonmetallic constituent components perhaps by creating a metal oxide of the nonmetallic constituent components, perhaps in a metals oxidation area, and magnetically attracting the created metal oxide. In some embodiments, oxidation may be achieved by reacting such constituent components with a negatively electrostatically enhanced water species, perhaps as injected into a gasifier process materials flow path, and magnetically attracting the reacted constituent component. Moreover, such magnetically isolated constituent components may be removed from a gasifier process flow path, for example perhaps by being gravimetrically deflected away from a gasifier process flow path and received into an electromagnetic drop well. Such gravimetric deflection of course may be enhanced by a magnet. In various embodiments, such an electromagnetic drop well may be located to receive removed constituent components prior to exit from a temperature varied environment, perhaps even after pyrolytic decomposition of a feedstock solids carbonaceous material. Removal of such magnetically isolated constituent components further may reduce abrasion within the solid carbonaceous materials gasifier system that otherwise may have been caused by the constituent component. Such removal also may assist in increasing the purity of a select product gas, increasing the BTU content of a select product gas, minimizing contaminants within a select product gas, or perhaps even creating a magnetic materials demagnetized select product gas.

In some embodiments, pyrolytically decomposed carbonaceous material, such as perhaps generated, devolatilized reactive vapor and atomized particulate material, may pass into and through a venturi injector (**13**) (FIGURE 3.3.6.2. ; 3.3.6.3; 3.3.6.5; 3.3.6.9; 3.3.6.**15**). This in turn may have a pressure-tight fitting to the inlet of multiple coil carbonaceous reformation vessel (**19**) (FIGURE 3.3.6.2. ; 3.3.6.3; 3.3.6.4; 3.3.6.5; 3.3.6.**15**). A venturi injector (**13**) (FIGURE 3.3.6.2. ; 3.3.6.3; 3.3.6.5; 3.3.6.9; 3.3.6.**15**) may be connected directly to an input, perhaps an inlet pipe opening, of the innermost reformation coil (**15**) (FIGURE 3.3.6.2. ; 3.3.6.3; 3.3.6.6; 3.3.6.7; 3.3.6.8; 3.3.6.**15**), perhaps preliminary reformation coil, of a multiple coil carbonaceous reformation vessel. Venturi side-entry inputs may provide the option of produced select product gas, generated negatively electrostatically enhanced water species, or perhaps both to be injected into the reformation coils, for example perhaps at the initial entry opening of the first innermost reformation coil (**15**) (FIGURE 3.3.6.2. ; 3.3.6.3; 3.3.6.6;

3.3.6.7; 3.3.6.8; **14**). As an additional process safeguard, a side-stream small volume of select product gas may be made available for return injection such as into the multiple coil carbonaceous reformation vessel (**19**) (FIGURE 3.3.6.2. ; 3.3.6.3; 3.3.6.4; 3.3.6.5; 3.3.6.**15**), perhaps even such as into and through the venturi injector (**13**) or through venturi injector (**17**) (FIGURE 3.3.6.2. ; 3.3.6.3; 3.3.6.9; 3.3.6.10; 3.3.6.**15**). This may provide for additional select product gas motive velocity and pressure perhaps to move carbonaceous materials entrained in a gasifier process flow continuously into and through all reformation coils (**15**), (**16**) and (**18**) (FIGURE 3.3.6.2. ; 3.3.6.3; 3.3.6.6; 3.3.6.7; 3.3.6.8; 3.3.6.**15**) of a multiple coil carbonaceous reformation vessel **19**. In the event of a momentary mechanical or process depletion availability of accessible flue gas, select product gas, or perhaps both, a rapid shutdown purge may be made available for providing a complete multiple coil carbonaceous reformation vessel vent-cleaning, perhaps by back-feeding system process water into the multiple coil carbonaceous reformation vessel (**19**) (FIGURE 3.3.6.2. ; 3.3.6.3; 3.3.6.4; 3.3.6.5; 3.3.6.**15**). Coil latent heat may provide thermal energy to produce an immediate steam cleaning action, if and when required due to an emergency shutdown circumstance. The availability of providing negatively electrostatically enhanced mist injection directly into the initial reformation coil, at the point of venturi injection (**13**) (FIGURE 3.3.6.2. ; 3.3.6.3; 3.3.6.5; 3.3.6.9; 3.3.6.15), and/or venturi injector (**17**) (FIGURE 3.3.6.2. ; 3.3.6.3; 3.3.6.9; 3.3.6.10; 3.3.6.**15**), may further provide near instantaneous and immediate steam reformation reaction-control. If either high surfactant or tarry or waxy chemistry exists, or if very dry input feedstock solids carbonaceous material is to be processed, or even if additional, perhaps merely more flexible, process control variables may be desired, an element such as a venturi injector (**17**) (FIGURE 3.3.6.2. ; 3.3.6.3; 3.3.6.9; 3.3.6.10; 3.3.6.**15**) may be applied with an alternate embodiment for venturi injector (**13**) also shown.

In some embodiments, a negatively electrostatically enhanced water species, possibly including negatively electrostatically enhanced steam, may be added to a temperature varied environment. Such addition of a negatively electrostatically enhanced water species may represent a dynamically adjustable process determinative parameter implemented in the temperature varied environment. The negatively electrostatically enhanced water species perhaps may be routed through a return injection line (**51**) (FIGURE 3.3.6.2. ; 3.3.6.3), and perhaps may be preheated to an elevated temperature, such as perhaps about 1,800° F., and may possibly be preheated via routing through a box furnace enclosure (**26**) (FIGURE 3.3.6.2. ; 3.3.6.3; 3.3.6.**14**; 3.3.6.**15**). Adding the negatively electrostatically enhanced water species may involve mist spraying, perhaps using a venturi (not shown), upon incoming feedstock solid carbonaceous material that may be engaged by a track feeder (**10**) (FIGURE 3.3.6.2. ; 3.3.6.3; 3.3.6.4; 3.3.6.5; 3.3.6.**14**). External valve control may be included to allow the addition of the negatively electrostatically enhanced water species to be metered for determining an optimum process control set-point.

Embodiments may further involve adding a flue gas to the temperature varied environment, perhaps such a pressurized flue gas, a flue gas pressurized to at least 80 psi, or a flue gas in motion at a rate of about 75-100 cfm. Such addition of a flue gas may represent a dynamically adjustable process determinative parameter. For example, such addition of a flue gas may be used to further affect temperature of a feedstock solids carbonaceous material, and may provide motive force pressurization within the temperature varied environment. For example, perhaps simultaneous to the point of negatively electrostatically enhanced water species injection into the temperature varied environment, additional hot flue gas may be compressed and pressure regulated, perhaps to at least about 80 psi, from an exhaust flue gas compressor (**8**) (FIGURE 3.3.6.2. ; 3.3.6.3; 3.3.6.**13**). This may be coactively venturi-injected (not shown) such as to perhaps join a spray of the negatively electrostatically enhanced water species mixing with incoming feedstock solids carbonaceous material. This may not only establish further process determinative parameters that may allow the negatively electrostatically enhanced water species to react and assist in accelerating more complete pyrolytic decomposition, but may also provide for the injection of additional reactive flue gas carbon monoxide content, perhaps to accelerate vapor pressure reactions. The injection of pressurized flue gas also may assist in regulating and perhaps maintaining pressure within the temperature varied environment, for example perhaps 80 psi or higher control pressure if desired. Also, heat from an added preheated flue gas may be employed to contribute to the overall heat balance, perhaps reducing heat requirements from other gasifier system elements.

Moreover, embodiments further may provide for adding select product gas to achieve the same process control benefits as adding flue gas, adding wet select product gas, adding dry select product gas, adding recycled select product gas, adding a scrubber recycled tar, adding a scrubber recycled phenol, adding scrubber recycled carbon dioxide, and adding a scrubber recycled solid to a temperature varied environment. Such additions of course also may represent dynamically adjustable process determinative parameters.

Accordingly, in various embodiments, a temperature varied environment may incorporate one or more dynamically adjustable process determinative parameters, perhaps utilized singly or in combination. Initial feedstock solids carbonaceous materials decomposition, perhaps pyrolytic decomposition, may occur perhaps across a moving track feeder bottom-side length of progressive temperature increase through a temperature gradient. In embodiments, this may range from approximately 300° F. to 900° F., and may even occur as movement guides, perhaps track flights, scrape forward carbonaceous material, as perhaps along a surface of a track feed heater contact plate (not shown). Feedstock solids carbonaceous material may move forward and may gradually both dissociate and volatilize into smaller solids and particulates, and initial carbon conversion gases may be released. Further, the feedstock solids carbonaceous material may partially liquefy, perhaps along with organic content beginning to volatilize into hydrogen gas, carbon monoxide gas, hydrocarbon vapors, and perhaps other select product gas components. By controlling and adjusting the retention time, perhaps through track feeder speed variation, the feedstock solids carbonaceous material may be subjected to and may pass through the majority of any or all char decomposition reactions, and perhaps liquefaction stages. There may even be a near 100% throughput delivery of decomposed, perhaps pyrolytically decomposed, carbon-bearing fine particulate material and initial devolatilized gas cross-over into a subsequent gasifier system processing stage, such as perhaps a multiple coil carbonaceous reformation vessel. Any residual amount of remaining larger-particle char, solids, or inorganic metallic or inert material, including perhaps para-magnetic organic or metal compounds, may become attracted and isolated into a electromagnetic drop well (**12**) (FIGURE 3.3.6.2. ; 3.3.6.3; 3.3.6.14). These isolated, perhaps smaller volume materials may be intermittently transferred through an airlock receiver (not shown) to an external container. Any incompletely decomposed carbonaceous material of larger particle size perhaps may be screen classified and separated away from other drop-well silica or magnetic debris and recycle returned, such as back to a walking floor feed hopper.

Not only may the physical kinetics of changing track feeder speed allow the decomposition completion time to become optimized for various chemistries of different feedstock solids carbonaceous materials, but other synergistic dynamically adjustable process determinative parameters may be applied, either individually or collectively, perhaps to optimize near total decomposition, and perhaps to maximize initial devolatilization gaseous transfer such as to subsequent gasifier system processors. Dynamically adjustable process determinative parameters may exist, perhaps such as: heat and temperature variations which may be altered or increased; flue gas injected concentrations, perhaps carbon monoxide ratios, may be adjusted; negatively electrostatically enhanced water species dilution and injection ratios may be modified to accelerate carbon shift and steam reformation; throughput select product gas components pressure reaction velocities may be altered; and resultant carry-through vapor and fine, perhaps carbon-bearing, particulate or ash mass balance ratios may be modified and adjusted to achieve optimum select product gas production volumes.

A solid carbonaceous materials gasifier system in various embodiments may be configured to recycle various substances routed through a gasifier process flow path. Such recycling may involve returning materials put through or perhaps generated at a later processing stage within the carbonaceous materials gasifier system to an earlier processing stage of the carbonaceous materials gasifier system. In various embodiments, such return may be via a recycle path appended to the later processing stage and routed to a recycle input joined to the gasifier process flow path at an earlier processing stage. Moreover, recycling in various embodiments may involve significantly internally recycling, for example where a substantial majority of the recycle material may be retained within the solid carbonaceous materials gasifier system, including perhaps all or nearly all of such a recycle material. Recycling in various embodiments perhaps even may include exceeding an environmental standard for recycling such materials.

For example, a generalized process flow for a solid carbonaceous materials gasifier system in some embodiments may involve initially processing at least a portion of a feedstock solids carbonaceous material, creating an initially processed carbonaceous material, subsequently processing the initially processed carbonaceous material, perhaps to generate at least some components of a select product gas, and creating a subsequently processed carbonaceous material. The subsequently processed carbonaceous material perhaps may be selectively separated, as into a first processed material portion and a second processed materials portion. The first processed materials portion then perhaps may be returned, for example perhaps utilizing an appended recycle path to a recycle input of the gasifier process flow path. Some embodiments perhaps may involve mixing the returned first processed materials portion with an additionally input carbonaceous material, for example perhaps with a feedstock solids carbonaceous materials re-mixer, and reprocessing.

Of course, the steps of initially processing, subsequently processing, and reprocessing may involve any appropriate kind of processing of carbonaceous material consistent with the gasification principles discussed herein—all that may be required is that the step of initially processing occur before the step of subsequently processing, and that the step of subsequently processing occur before the step of reprocessing. For example, these steps of processing may include pretreating a carbonaceous material, pyrolytically decomposing a carbonaceous material, carbonaceously reforming a carbonaceous material in a multiple coil carbonaceous reformation vessel, preliminarily carbonaceously reforming a carbonaceous material in a preliminary reformation coil, secondarily carbonaceously reforming a carbonaceous material in a secondary reformation coil, and tertiarily reforming a carbonaceous material in a tertiary reformation coil. In addition, returning in various embodiments may be implemented perhaps by a venturi, or perhaps even a venturi injector, for example perhaps to maintain pressure conditions or flow rate conditions through a recycle path, for example such as a pressure from about 50 psi to about 100 psi or a flow rate from about 2,000 fpm to about 8,000 fpm.

Moreover, recycling in various embodiments may involve selecting a recycle path, perhaps as from a multiply routable path. Such a multiply routable path may provide two or more recycle path options through which recycled materials may be returned. For example, with reference to the generalized process flow described herein, one example of a multiply routable path may involve initially processing in a pyrolysis chamber, subsequently processing in a preliminary reformation coil, returning a first processed materials portion to the pyrolysis chamber, and reprocessing in the pyrolysis chamber. Another example may involve initially processing in a preliminary reformation coil, subsequently processing in a secondary reformation coil, returning the first processed materials portion to the preliminary reformation coil, and reprocessing in the preliminary reformation coil. Of course, these are merely examples illustrative of some possible configurations for a multiply routable path in some embodiments, and should not be construed to limit the possible configurations for a multiply routable path consistent with the principles described herein.

In various embodiments, materials routed through a gasifier process flow path may be selectively separated. Such selective separation perhaps may involve selecting a property of the material to be separated and effecting separation by utilizing that property. Examples of such selective separation perhaps may include screening, solubilization, magnetism, or the like. In some embodiments, selective separation may be accomplished through the vortex action of a cyclone. For example, embodiments may include operating a cyclone at conditions including perhaps from 50 psi to 100 psi, 1,640° F. to 1,800° F., and 2,000 fpm to 8,000 fpm, and achieving the selective separation of gasifier process flow path materials accordingly. Moreover, selectively separating may include on the basis of particle size, for example perhaps selectively separating carbonaceous particles of at least 350 micron particle size, selectively separating carbonaceous particles of at least 150 micron particle size, selectively separating carbonaceous particles of at least 130 micron particle size, selectively separating carbonaceous particles of at least 80 micron particle size, selectively separating carbonaceous particles of at least 50 micron particle size, selectively separating carbonaceous particles of at least 11 micron particle size, selectively separating carbonaceous particles of at least 3 micron particle size, and selectively separating ash. Other modes of selectively separating may include physically separating, separating by phase, separating by density, separating by screening, separating by incompletely pyrolytically decomposed carbonaceous material, separating by incompletely carbonaceously reformed material, separating by heterogeneous composition, and the like. Moreover, selectively separating consistent with the techniques described herein may remove certain impurities from a gasifier process flow, perhaps with the result of increasing the purity of a select product gas, increasing the BTU value of a select product gas, or perhaps minimizing contaminants within a select product gas. In various embodiments, such resulting products may be considered to be separation products resulting from the act of selectively separating as described herein.

A gasifier process flow path in various embodiments may be routed through a multiple coil carbonaceous reformation vessel (**19**) (FIGURE 3.3.6.2. ; 3.3.6.3; 3.3.6.4; 3.3.6.5; 3.3.6.**15**). For example, a process flow may include pyrolytically decomposed carbonaceous materials from a pyrolysis chamber, perhaps such as released gas and carbon-bearing particulate matter pressurized out of a temperature varied environment. A multiple coil reformation vessel may include two or more reformation coils through which a process flow may be routed. Carbonaceous materials entrained in the process flow may be reformed within each such reformation coil. Such carbonaceous reformation may encompass perhaps simply changing the form of such carbonaceous materials, as for example perhaps from or into select product gas components, from or into incompletely reformed carbonaceous materials, from or into ash, or perhaps from or into various types of contaminants. In some embodiments, carbonaceous reformation may involve vaporizing a carbonaceous material, for example such as vaporizing hydrocarbons or vaporizing select product gas components. Moreover, reformation coils perhaps may simply provide a coiled path through which a process flow may be routed during a carbonaceous reformation stage in a solid carbonaceous materials gasifier system, in some embodiments for example as perhaps through a coiled tube, pipe, conduit, or the like. A multiple coil carbonaceous reformation vessel may include a preliminary reformation coil, a secondary reformation coil, a tertiary reformation, and perhaps one or more additional reformation coils as may be desired to achieve carbonaceous reformation.

Embodiments may include complementarily configuring at least two reformation coils, which may involve positioning the reformation coils relative to each other to improve the efficacy of the carbonaceous reformation process. For example, some embodiments may involve helically nesting at least two carbonaceous reformation coils. Such a helically nested arrangement perhaps may improve the efficacy of the carbonaceous reformation process by reducing the size occupied by a multiple coil carbonaceous reformation vessel, or perhaps by permitting the selective distribution of heat applied to the helically nested configuration, such as wherein heat may be applied to one coil and radiated from that coil to another helically nested coil. In this manner, individual reformation coils may be seen to act as radiators. For example, embodiments may involve a preliminary reformation coil, a secondary reformation coil, and a tertiary reformation coil in a helically nested configuration, wherein heat applied to the helically nested configuration may be variably triply distributed from one coil to another, and the configuration may act as a tripart reformation coil radiator. Of course, it may be appreciated that the manner in which two or more reformation coils may be complementarily configured and the location and modality in which heat may be selectively applied may create a variety of arrangements that may represent selectively adjustable process control parameters, perhaps even dynamically adjustable process determinative parameters.

For example, in some embodiments, a horizontal helically nested configuration of multiple reformation coils such as one inside the other may be applied. Such a configuration may provide a high temperature helical coil reformation environment that may establish the longest length within the smallest cube design volume space and footprint, perhaps as shown in assembly (**19**) and embodiments (**15**), (**16**) & (**18**) (FIGURE 3.3.6.2. ; 3.3.6.3; 3.3.6.4; 3.3.6.5; 3.3.6.6; 3.3.6.7; 3.3.6.8; 3.3.6.**15**). As one example, assembly (**19**) may have a nesting configuration design that may provide an extremely efficient heat transfer cubical unit whereby the maximum amount of helical reformation coil lineal footage of pipe is packed into the smallest cubic volume of box furnace enclosure (**26**) (FIGURE 3.3.6.2. ; 3.3.6.3; 3.3.6.**14**; 3.3.6.**15**) space. This configuration may provide radiant heat transfer from the outermost coil (**18**) (FIGURE 3.3.6.2. ; 3.3.6.3; 3.3.6.6; 3.3.6.7; 3.3.6.8; 3.3.6.**15**) to the innermost coil (**15**) (FIGURE 3.3.6.2. ; 3.3.6.3; 3.3.6.5; 3.3.6.7; 3.3.6.8; 3.3.6.**15**) and vice versa. This may reduce an overall furnace BTU combustion heat and the input select product gas energy requirement as necessary such as perhaps to hold the furnace temperature constant in the 1,600° F. to 1,800° F. temperature range.

The helical reformation coil assembly (**19**) inside of the furnace may be heated and held at an elevated level, perhaps such as from about 1,600° F. to about 1,800° F. Further, the furnace may be heated by a computerized and auto-controlled combustive burner manifold system (**14**) (FIGURE 3.3.6.2. ; 3.3.6.3; 3.3.6.**15**; 3.3.6.10). A combustive burner may utilize recycled select product gas as the combustible fuel source, perhaps with an alternate connection to an external fuel source, perhaps a pressurized propane tank, to be supplied as an initial startup fuel source or the like. In the helical reformation coil assembly **19**, a burner manifold forced air combustion system may hold the temperature of all three reformation coils (**15**), (**16**) and (**18**) (FIGURE 3.3.6.2. ; 3.3.6.3; 3.3.6.6; 3.3.6.7; 3.3.6.8; 3.3.6.**15**) elevated, perhaps such as at a minimum of about 1,600° F. in order to facilitate carbonaceous reformation, as for example where substantially all atomized carbon particulate material moving through the combined length of all three reformation coils may be substantially completely carbonaceously reformed (perhaps such as in the presence of steam) into select product gas components, such as perhaps carbon monoxide and hydrogen gases. In embodiments, a combustive burner manifold system (**14**) (FIGURE 3.3.6.2. ; 3.3.6.3; 3.3.6.**15**) may be placed on the inside of the box furnace enclosure (**26**), for example perhaps at the bottom inside wall and perhaps further extended one-third upward on two opposing sidewalls (not shown). Burner jet-nozzles may penetrate through the box furnace enclosure (**26**) (FIGURE 3.3.6.2. ; 3.3.6.3; 3.3.6.**14**; 3.3.6.**15**), perhaps with pressure-tight weldments, and perhaps may further penetrate through a perhaps twelve inch thickness of high temperature glass wool insulation (perhaps with ceramic heat shield cones placed around each burner jet-nozzle pipe). Nozzles may be strategically angle positioned to produce a selectively applied heat distribution, such as perhaps an evenly distributed blanket of heat across the entire reactor embodiment surfaces (and perhaps throughout the three-dimensional helical nest structure) of the helical reformation coil configuration (**19**) (FIGURE 3.3.6.2. ; 3.3.6.3; 3.3.6.4; 3.3.6.5; 3.3.6.**15**). To provide maximum heat and strength longevity, the reformation coils (**15**), (**16**) and (**18**) (FIGURE 3.3.6.2. ; 3.3.6.3; 3.3.6.6; 3.3.6.7; 3.3.6.8; 3.3.6.**15**) may be fabricated from high strength and high temperature Inconel® or other such metal pipe, or other alternate and appropriate metallic materials. Reformation coil (such as per each nesting coil) diameters may vary from about three inches to about eight inches in diameter and the pipe lengths may vary proportionally as dependent upon the daily tonnage of input feedstock volume that is to be processed, perhaps in order to maintain optimum process gas velocity throughout the multiple carbonaceous reformation coil vessel and any selective separators incorporated therein.

Operating conditions of a preliminary reformation coil, perhaps as exemplified within helical reformation coil assembly (**19**), may include an operating condition of at least 50 psi to 100 psi, 1,640° F. to 1,800° F., and a flow rate from 5,000 fpm to 20,000 fpm. Similarly, operating conditions of a secondary reformation coil, perhaps as exemplified within helical reformation coil assembly (**19**), may include an operating condition of at least 50 psi to 100 psi, 1,640° F. to 1,800° F., a flow rate from 5,000 fpm to 20,000 fpm, and perhaps a reformation time of up to about 5 seconds. Moreover, operating conditions of a tertiary reformation coil, perhaps as exemplified within helical reformation coil assembly (**19**), may include an operating condition of at least 50 psi to 100 psi, 1,750° F. to 1,850° F., a flow rate from 5,000 fpm to 20,000 fpm, and perhaps a reformation time of up to about 4 seconds. Total reformation time of a multiple coil carbonaceous reformation vessel, again as perhaps exemplified by helical reformation coil assembly (**19**), may be from about 4 seconds to about 10 seconds.

Moreover, embodiments may include adding reaction beneficial materials to at least one reformation coil of a multiple coil reformation vessel, for example such as adding before a preliminary reformation coil, adding between a preliminary reformation coil and a secondary reformation coil, adding between a secondary reformation coil and a tertiary reformation coil, adding after a tertiary reformation coil, utilizing a venturi injector, utilizing a flue gas, utilizing a pressurized flue gas, utilizing a preheated flue gas, and perhaps via a reaction beneficial materials input.

Carbonaceously reforming within a multiple coil carbonaceous reformation vessel in various embodiments may include selectively separating carbonaceous materials at various points within the vessel with a carbonaceously reformed materials selective separator, for example perhaps via vortex action using a cyclone. One or more selective separators perhaps may be employed and placed at suitable locations within the multiple coil carbonaceous reformation vessel, for example perhaps to achieve selective separation before a preliminary reformation coil, between a preliminary reformation coil and a secondary reformation coil, between a secondary reformation coil and a tertiary reformation coil, and perhaps after a tertiary reformation coil. Selectively separating in this manner perhaps may allow progressive refinement of a quality of a carbonaceous material as it is routed through the reformation coils of a multiple coil reformation vessel, for example, perhaps by progressively reducing the particle size of carbonaceous particles transiting from coil to coil. Moreover, such selectively separated carbonaceous materials may be recycled, for example via a carbonaceously reformed materials recycle path, to any suitable gasifier process flow path location, such as a pretreatment area, a pyrolysis chamber, a preliminary reformation coil, a secondary reformation coil, and perhaps by utilizing a venturi injector, utilizing a flue gas, utilizing a pressurized flue gas, utilizing a preheated flue gas, or the like.

In some embodiments, for example, a cyclone (**20**) (FIGURE 3.3.6.2. ; 3.3.6.3; 3.3.6.**15**) perhaps may be fitted to an end outlet of a preliminary reformation coil (**15**) (FIGURE 3.3.6.2. ; 3.3.6.3; 3.3.6.6; 3.3.6.7; 3.3.6.8; 3.3.6.**15**). Such a cyclone may be fabricated from high temperature Inconel® or other alternate and appropriate metallic materials or the like. In embodiments, a cyclone perhaps may be engineered to remove carbonaceous materials, such as perhaps the majority of char carry-through particulate material such as that is about 80 to about 150 microns in particle size, or larger. A venturi, perhaps a venturi injector, may be joined at the cyclone bottom exit port, and perhaps may control a periodic emptying of accumulated selectively separated carbonaceous materials, perhaps such as char debris, for recycling back such as into a pyrolysis chamber. Such recycling perhaps may allow additional pyrolytic decomposition of the recycled carbonaceous material, for example carbon containing char particulates, to occur. The venturi, perhaps a venturi injector, may be provided with a side-stream injection port from a produced select product gas delivery manifold (**21**) (FIGURE 3.3.6.2. ; 3.3.6.3; 3.3.6.9; 3.3.6.10; 3.3.6.**15**) and may also provide perhaps a variable differential pressure that may assist in clearing the cyclone of selectively separated carbonaceous material. Moreover, a venturi injector unit (**17**) (FIG. 3.3.6.4) may be connected, perhaps flange connected, to the top outlet of the cyclone (**20**), and perhaps may utilize nuclear industry design high temperature flexatalic gaskets and bolt assemblies. A venturi injector (**17**) further may be connected, perhaps flange connected, such as to an inlet opening of a secondary reformation coil (**16**) (FIGURE 3.3.6.2.; 3.3.6.3; 3.3.6.6; 3.3.6.7;

3.3.6.8; 3.3.6.**15**) and perhaps may provide additional turbulent flow steam reformation into the reformation coil (**16**).
A carbonaceous materials selective separation sequence perhaps may be repeated for a secondary reformation coil, perhaps relative to applying a cyclone (**22**) (FIGURE 3.3.6.2. ; 3.3.6.3; 3.3.6.**15**). A cyclone (**22**) may act to remove carbonaceous materials, perhaps such as carry-through char particulates down to about 50 to about 130 microns in particle size, perhaps by connecting, perhaps flange connecting, the cyclone from an exit opening of the secondary reformation coil (**16**) (FIGURE 3.3.6.2. ; 3.3.6.3; 3.3.6.6; 3.3.6.7; 3.3.6.8; 3.3.6.15) to the entry opening of the tertiary reformation coil (**18**) (FIGURE 3.3.6.2. ; 3.3.6.3; 3.3.6.6; 3.3.6.7; 3.3.6.8; 3.3.6.**15**). A venturi injector (**17**) (FIG. 3.3.6.2; 3.3.6.3; 3.3.6.9; 3.3.6.10; 3.3.6.**15**) may be also installed, as perhaps within pipe flange connections between the top exit of the cyclone classifier (**22**) and the entry point into the tertiary reformation coil (**18**). This additional installed location of a venturi injector (**17**) (FIG. 3.3.6.2; 3.3.6.3; 3.3.6.9; 3.3.6.10; 3.3.6.15) may further provide accelerated carbonaceous reformation, perhaps to additionally decrease CO_2 and other hydrocarbon concentrations in the select product gas stream being generated. As with the cyclone (**20**) (FIGURE 3.3.6.2. ; 3.3.6.3; 3.3.6.15), a bottom exit venturi, perhaps venturi injector possibly with recycled select product gas side-stream injection, may be provided that may work on differential pressure to periodically empty selectively separated carbonaceous material, such as char particulate material, perhaps recycled back such as into the pyrolysis track feeder or into a preliminary reformation coil.

This may provide for the recycle recovery of carbonaceous materials, perhaps such as most all char organic carbon content, perhaps via the re-processing of recovered char particulate material within a preliminary reformation coil.

Two cyclones (**23**) (FIGURE 3.3.6.2. ; 3.3.6.3; 3.3.6.**15**), perhaps tertiary final polish cyclone classifiers, may be included and may be connected, perhaps flange connected, to an exit opening such as of a tertiary reformation coil (**18**) (FIGURE 3.3.6.2. ; 3.3.6.3; 3.3.6.6; 3.3.6.7; 3.3.6.8; 3.3.6.**15**). These perhaps may be provided as pipe arrangements in series with each other, and perhaps may selectively separate and remove any remaining carbonaceous materials or ash carry-through particulate material, for example perhaps in the particle size removal ranges of: 10% of 1 micron size particles being removed; 25% of 2 micron size particles being removed; 35% of 3 micron size particles being removed; and even 100% of 15 micron size (or above particle size) particles being removed. In embodiments, two series-staged polishing cyclones (**23**) may be utilized perhaps to ensure that any possible post contamination of carbonaceous materials, such as perhaps still reactive char materials, or ash substrate carrying through to contaminate final produced select product gas may be avoided. Further, an ash removal system, perhaps such as an auto-purge double air-lock valve system, may be employed such as to perhaps periodically empty any fine ash particulate material from such cyclones into an ash receiver system and automated removal section.
A gasifier process flow path in various embodiments may be routed through an ash removal area (**78**) (FIGURE 3.3.6.2.; 3.3.6.3) of a solid carbonaceous materials gasifier system. This may be illustrated conceptually in one embodiment in FIGURE 3.3.6.2. &2. In embodiments, fine particulate material perhaps may pass through a multiple coil carbonaceous reformation vessel. This fine particulate material may be substantially, perhaps even 95% or more, selectively separated via cyclones (**23**) (FIGURE 3.3.6.2.; 3.3.6.3; 3.3.6.**15**). The majority of

these selectively separated fine particulate materials may be inert and may exist as non-carbon and non-reactive ash substrate. Such ash substrate material may be selectively separated from the gasifier process flow path perhaps to eliminate nearly all particulate contamination and perhaps to ensure that a high quality purity of the final select product gas is maintained.

An ash removal handling system, perhaps airtight and pressurized, may be provided whereby two cyclones (**23**) (FIGURE 3.3.6.2.; 3.3.6.3; 3.3.6.**15**) each may empty collected ash, perhaps via a sealed conduit pipe connection through a box furnace enclosure (**26**) (FIGURE 3.3.6.2. ; 3.3.6.3; 3.3.6.**14**; 3.3.6.**15**), and perhaps such as into smaller ash receiver tanks (**24**) (FIGURE 3.3.6.2. ; 3.3.6.3; 3.3.6.**16**). The ash may be withdrawn from the two cyclones perhaps through a dual airlock and triple, perhaps slide actuation, valve system (**7**) (FIGURE 3.3.6.2. ; 3.3.6.3; 3.3.6.**16**). In embodiments, as the top and bottom valves may actuate to the open position, the middle valve may remain closed. Intermittently, hot ash may fall by gravity into the top receiver tank and the bottom receiver tank (**24**) (FIGURE 3.3.6.2. ; 3.3.6.3; 3.3.6.16). Ash from the bottom receiver tank (perhaps somewhat cooled) may fall down and into an elliptical conveyor screw trough and separated ash recovery unit (**25**) (FIGURE 3.3.6.2. ; 3.3.6.3; 3.3.6.**16**) perhaps to be subsequently transported to adjacent mobile storage, perhaps cooling bins. Valves, such as slide valves (**7**) may be air-operated and may cycle open and closed on a reciprocal time basis perhaps such as perhaps approximately every 30 minutes or as controlled by process computer set-points. Adjustable time frequency of valve actuation may provide for additional ash cooling time to occur within the ash receiver tank (**24**). Further, ash receiver tanks and even the slide valve assemblies may be constructed of high temperature steel materials. The removed ash, perhaps as dependent upon the input carbonaceous feedstock chemical composition, may represent an item with resale potential as a high grade mineral fertilizer additive, and perhaps may be applied as a cementaceous filler in cement construction block manufacturing operations.

A solid carbonaceous materials gasifier system in various embodiments may generate a contaminated select product gas. Such contaminants may include perhaps simply any substances tending to reduce the quality of a select product gas. Examples of such contaminants may include for example chemical by-products, thermal by-products, pyrolytic decomposition by-products, carbonaceous reformation by-products, carbon dioxide, carbonate, insoluble solids, tar, phenol, hydrocarbon, and other particulates. Accordingly, embodiments may provide for isolating a significant number of contaminants and creating a scrubbed select product gas. This may be illustrated conceptually in process embodiments in FIGURE 3.3.6.2. & 3.3.6.3. Such isolation may be accomplished in any suitable manner consistent with the principles discussed herein, for example perhaps by pyrolysis, screening, magnetism, vortex action, or the like. In some embodiments, such isolation may be accomplished by solubilizing the contaminants in a contaminant solubilization substance, perhaps as may be disposed within a select product gas components scrubber through which said gasifier process flow path may be routed. Such solubilization further may comprise increasing the purity of a select product gas, increasing the BTU value of a select product gas, minimizing contaminants within a select product gas, or perhaps even creating a scrubbed select product gas having one or more of these properties, consistent with the principles described herein.

A contaminant solubilization substance in certain embodiments may include a negatively electrostatically enhanced water species. Contaminant isolation may occur upon solubilization of contaminants in such a negatively electrostatically enhanced water species, perhaps via an oxidation reaction, a reduction reaction, an adsorption coagulation reaction, an absorption coagulation reaction, or the like. Accordingly, such solubilization may involve coagulating, separating, flocculating, precipitating, settling, condensing, polishing, filtering, removing via final polarized media polish filtration, and removing via electro-precipitation removal such contaminants.

Contaminant solubilization substances also perhaps may include chilled contaminant solubilization substances. For example, embodiments may include lowering the temperature of a select product gas via a chilled contaminant solubilization substance in a select product gas components scrubber, for example as from greater than about 1700° F. to less than about 175° F. Moreover, such use of a chilled contaminant solubilization substance to lower the temperature of a select product gas may prevent vitrification solidification of contaminants within the select product gas as it is cooled, with contaminants instead perhaps being solubilized in the contaminant solubilization substance with decontaminated select product gas being maintained in an unvitrified state.

Moreover, a select product gas components scrubber in various embodiments may include at least a primary solubilization environment and a secondary solubilization environment, for example perhaps a primary scrubber tank and a secondary scrubber tank. Such multiple solubilization environments perhaps may provide multiple stage scrubbing of a select product gas, for example as wherein one scrubbing stage may be insufficient to accomplish a desired level of scrubbing, or as wherein it may be desirable to spread various scrubbing steps over several stages, such as perhaps for reducing a temperature of a select product gas being scrubbed. For example, primarily solubilizing in a primary solubilization environment in some embodiments perhaps may be configured to lower a temperature a select product gas from greater than 1,700° F. to less than 550° F., and secondarily solubilizing in a secondary solubilization environment perhaps may be configured to lower a temperature a select product gas from greater than 450° F. to less than 150° F. Of course, multiple stage scrubbing may address other process parameters, for example as wherein a primary solubilization environment may be configured to remove 70% to 80% of contaminants from a select product gas, with a second solubilization environment configured to remove perhaps some additional fraction of remaining contaminants.

Accordingly, embodiments may involve mixing and injecting one or more negatively electrostatically enhanced water species, such as perhaps a large portion of ionized and perhaps highly reactive oxygen vapor gases perhaps utilizing singlet oxygen, into a select product gas components scrubber through which a gasifier process flow path may be routed. Contaminants entrained in the gasifier process flow path perhaps may then be solubilized into the water species. Such contaminants perhaps may be further removed from the water species in one or more of several separating devices which may be incorporated into the select product gas components scrubber. In such arrangements, negatively electrostatically enhanced water species and hot synthesis gas reaction contact may take place. Coalescence and oxidation of contaminants may occur and may cause CO_2 (perhaps oxidized to CO_3 agglomerates), insolubles, tars, phenols, and other hydrocarbon contaminants to flocculate, precipitate, and/or perhaps settle for final polarized media polish filtration electro-precipitation removal of said contaminants.

Moreover, embodiments of the inventive technology may provide additional select product gas final purification and cleanup systems. Some of these may be as specifically indicated in the depiction of an embodiment such as shown in a scrubber area (**79**), (FIGURE 3.3.6.2. ; 3.3.6.3; 3.3.6.**17**), which may include (but may not require) elements as follows:

-
  - element (**27**): an Insulated Crossover Pipe (perhaps 1800° F. Synthesis Gas) To Scrubber Tank Inlet Cylinder,
  - element (**28**): a Mix (perhaps Synthesis Gas/VIP™/Ionized Water) Injector Cylinder,
  - element (**29**): a VIP™ (Vapor Ion Plasma) Ionized Water And Synthesis Gas Primary Scrubber Tank With Temperature Reduction perhaps To 350° F.,
  - element (**30**): a VIP™ Ionized Water Spray Manifold,
  - element (**31**): a VIP™ Vapor Ion Plasma Generator,
  - element (**32**): a VIP™ Injection Ionized H_2O Spray Diffusers,
  - element (**33**): a Recirculation Flow (perhaps Doubled Walled) Tank and chilled water separation tank, such as for Tar/Phenols Drop-Out,
  - element (**34**): an Auto-Control H_2O Balance Valves,
  - element (**35**): a VIP™ Ionized Water and Synthesis Gas Secondary Scrubber Tank, such as for Final Hydrocarbon(s) Removal,
  - element (**36**): a Scrubber H_2O Recycle Recirculation Pump,
  - element (**37**): a VIP™ Cooling H_2O Return Manifold,
  - element (**38**): a Chilled Water Tank (Tars/Phenols) Bleed-Off Return perhaps As Recycle Recovery Back To a pyrolytic decomposition area (**75**) Track Feeder Devolatilization Zone, or perhaps To Be Separated In an auxiliary treatment area (**76**) Roto-Shear™ Concentrator Unit,
  - element (**39**): a Synthesis Gas (perhaps 350° F. Crossover) Pipe To Secondary Scrubber Tank,
  - element (**40**): a (perhaps Auto-Controlled) Temperature Chiller,
  - element (**41**): an Air/Liquid perhaps Serpentine Heat Exchanger,
  - element (**42**): a Delivery (perhaps 80° F.) Manifold To electrically filter (eFILT™) perhaps via a Polarized Media Filter,
  - element (**43**): an eFILT™ (perhaps Polarized Media Filter) Recirculation Pump,
  - element (**44**): an eFILT™ Influent Filtration Manifold,
  - element (**45**): an eFILT™ perhaps Polarized Media Filter, Per Fine (perhaps One Micron Particle Size) Solids Removal, Including "CO_2 Shift To CO_3" Removal,
  - element (**46**): a VIP™ Ionized H_2O and Solids Slurry By-Pass Line to Embodiment (**51**),
  - element (**47**): a Filtered VIP™ perhaps Ionized H_2O Recycle Return To Primary Scrubber Tank,
  - element (**48**): an eFILT™ Backwash Water To Holding and Settling Tank,
  - element (**49**): a Backwash H_2O Slurry Holding and Settling Tank,
  - element (**50**): a Recirculation Chilled Water Separation Tank Overflow,
  - element (**51**): a Common (VIP™/Ionized H_2O/Solids) Return To Track Feeder Injection,
  - element (**52**): a Synthesis Gas Side-Stream Manifold Feed To Reactor Combustion Burner,

- element (**54**): a Polish (H_2O Removal) Coalescer and Condenser,
- element (**55**): a Polish Synthesis Gas (Fine Micron) Filters,
- element (**56**): a Backwash Solids Roto-Shear (rS™) Screw Concentrator and Separator,
- element (**57**): a Scrubber Tank Level Indicator and Controller,
- element (**58**): a System Components Overflow Drain Line,
- element (**59**): an Overflow Holding Tank and a VIP™ Ionized H_2O and Backwash H_2O Collection Tank,
- element (**60**): a Synthesis Gas Delivery Compressor,
- element (**61**): a Drain Line To Systems Collection Receiver Flash-Evaporator Unit,
- element (**62**): a VIP™ Ionized H_2O Pump,
- element (**63**): an Outside Makeup Water Line,
- element (**64**): a Filter Backwash Water Input Line,
- element (**65**): a Concentrated Solids Transfer To (perhaps External) Recovery Unit,
- element (**69**): a Final CO_2 Separation (perhaps Molecular Sieve Unit) if required,
- element (**70**): a Final Output Highly Purified [perhaps 550 BTU to 650 BTU] Synthesis Gas (perhaps Stripped of NO_X, SO_X, CO_2 and Organic Vapors) Stream,
- element (**71**): a Safety (perhaps Auto-Pressure) Relief Valve,
- element (**72**): an External Flare (perhaps Auto-Ignition) System, and
- element (**73**): a VIP™ Ionized H_2O and Solids Slurry Pump.

In various embodiments, at least some isolated contaminants may be recycled within a solid carbonaceous materials gasifier system and reprocessed therein. Accordingly, embodiments may involve returning such isolated contaminants, for example via a contaminants recycle path appended to a select product gas components scrubber and returning to a contaminants recycle input of a gasifier process flow path. Moreover, such recycling may involve selecting a recycle path, perhaps as from a multiply routable path. Such a multiply routable path in some embodiments may be routed through a feedstock solids carbonaceous materials processor, a select product gas components scrubber, a contaminants recycle path, and a contaminants recycle input of a gasifier process flow path. Moreover, in various embodiments, routing a contaminants recycle path to a contaminants recycle input may involve routing to a recycle input of a pretreatment area, pyrolysis chamber, multiple coil carbonaceous reformation vessel, preliminary reformation coil of a multiple coil carbonaceous reformation vessel, secondary reformation coil of a multiple coil carbonaceous reformation vessel, or a tertiary coil of a carbonaceous reformation vessel. Additionally, a contaminants recycle path in various embodiments may include a venturi, or perhaps even a venturi injector, for example perhaps to assist in moving contaminants through the recycle path.
Various embodiments may include a select product gas components formation zone or gasification zone through which a gasifier process flow path is routed. Consistent with the principles described herein, such a select product gas components formation zone perhaps simply may be any portion of a gasifier process flow path in which select product gas components may be formed. For example, processing stages tending to generate carbon

monoxide content select product gas components, hydrogen content select product gas components, or perhaps controlled molar ratio select product gas components may be select product gas components formation zones in various embodiments. Moreover, embodiments also may include a select product gas formation zone. Again, consistent with the principles described herein, such a select product gas formation zone perhaps simply may be any portion of a gasifier process flow path in which a select product gas may be formed. Of course, such a select product gas may include any of various characteristics as described elsewhere herein.

A gasifier process flow path in various embodiments may be routed through a product gas combustion preparation auxiliary treatment area (**76**) (FIGURE 3.3.6.2. ; 3.3.6.**18**). Embodiments may provide the return of a side-stream of produced select product gas, perhaps combustible 550 BTU to 650 BTU per pound, perhaps as from a produced select product gas outlet conduit pipe (**52**) (FIGURE 3.3.6.2. ; 3.3.6.3) to a combustive burner (**14**) (FIGURE 3.3.6.2. ; 3.3.6.3; 3.3.6.**15**). This may further extend from the produced gas outlet pipe (**52**) to provide an optional select product gas feed to a venturi feed pipe (**53**) (FIGURE 3.3.6.2. ; 3.3.6.3; 3.3.6.**18**), perhaps a venturi injector, providing inlet access to a multiple coil carbonaceous reformation vessel or the like. Combustion sustaining operations fuel may be autonomously provided by a recycle return, perhaps at a level of 15% or less of the total select product gas volume being generated.

Embodiments may include an air separation unit (**66**) (FIGURE 3.3.6.2. ; 3.3.6.3; 3.3.6.**18**), perhaps including an air intake and a nitrogen depletion area to deplete at least some nitrogen from taken in air. In this manner, a supply of enriched oxygen air flow may be generated and nitrogen content perhaps may be reduced within a solid carbonaceous materials gasifier system. For example, an oxygen enrichment line may be routed to a combustive burner whereby oxygen concentration input may be increased, for example perhaps such as by approximately 30%, which may in turn reduce a recycle requirement of select product gas such as to support furnace combustion operational temperatures, at a level of perhaps less than 10% of the recycle requirement. Moreover, an air separation unit (**66**) (FIGURE 3.3.6.2. ; 3.3.6.3; 3.3.6.**18**) may greatly deplete the nitrogen content in a combustion air intake stream, for example as may supply combustion operations at one or more combustive burners, which may substantially reduce process carry-through of nitrogen contaminants into the gasifier process flow path, including perhaps the final produced select product gas. Nitrogen oxides contamination and emission possibilities may be greatly reduced, eliminated, or may even become virtually non-existent. A combustion adjustable baffle proportioning flow air fan (**67**) (FIGURE 3.3.6.2. ; 3.3.6.3; 3.3.6.**18**) may be provided to meter atmospheric air intake, with recycled select product gas (perhaps with air separation unit (**66**) enriched oxygen air flow), perhaps as a forced draft combustible admixture gas flow into a combustive burner (**14**). Additionally, a side-stream oxygen enrichment line (**68**) (FIGURE 3.3.6.2. ; 3.3.6.3; 3.3.6.**18**) may be connected, perhaps as a bypass pipe connection, to a negatively electrostatically enhanced water species generation unit, for example perhaps one or more VIP™ Vapor Ion Plasma generator units (**31**) (FIGURE 3.3.6.2. ; 3.3.6.**3**; 3.3.6.**11**; 3.3.6.**17**). The input addition of a more concentrated oxygen addition to such units, for example such as an activated oxygen content, may greatly enhance the output of negative electrostatic enhancement species, for example perhaps vapor ion plasma singlet oxygen or peroxyl ion concentrations as injected into an ionized oxygen water stream, as may be applied throughout a solid carbonaceous materials gasifier system in various embodiments. Accordingly, embodiments may provide for a nitrogen depleted select product gas, which in fact may be a nitrogen oxide content minimized select product gas, a purified select product gas, or even a high BTU content select product gas.

A solid carbonaceous materials gasifier system in various embodiments may subject to an input feedstock solids carbonaceous material to a variety of chemical reaction sequences. A basic chemical reaction sequence often considered in the production of synthesis gas may be represented in Table 1 as follows, though the inventive technology may be applicable to a variety of chemical reaction sequences and should not be considered as limited to just the following

Table 1

In some embodiments, process determinative parameters of the inventive technology may permit manipulation of this and other chemical reaction sequences, and indeed perhaps even non-chemical processing aspects, in a solid carbonaceous materials gasifier system to generate high energy content, purified, or even high yield select product gas, perhaps such as by finishing the chemical reaction sequence to substantial completion for a majority of or perhaps substantially all of the carbon content in a feedstock solids carbonaceous material. For example, embodiments may involve dynamically adjusting at least one such process determinative parameter, as perhaps with a dynamically adjustable process flow regulator. The dynamic character of such an adjustment may stem from the capability of effecting such adjustments while the gasifier system is operating. For example, embodiments may include sensing at least one process condition with a process condition sensor and adjusting at least one process determinative parameter with a sensor responsive dynamically adjustable flow regulator based on the sensed condition. Sensing, of course, may be accomplished in any of a variety of suitable manners, such as sensing a temperature, sensing a pressure, sensing a process materials composition, sensing a carbon monoxide content, sensing a carbon dioxide content, sensing a hydrogen content, sensing a nitrogen content, sensing a sulfur content, sensing via a gas chromatograph, sensing via a mass spectrometer, and the like. Similarly, any of a variety of adjustments may be dynamically affected in response by an appropriate process flow regulator, such as suitable inputs, injectors, separators, returns, timers, and the like. Examples of such adjustments may include adding water, adding preheated water, adding recycled water, adding a negatively electrostatically enhanced water species, adding a preheated negatively electrostatically enhanced water species, adding a recycled negatively electrostatically enhanced water species, adding steam, adding recycled steam, adding negatively electrostatically enhanced steam, adding recycled negatively electrostatically enhanced steam, adding flue gas, adding preheated flue gas, adding pressurized flue gas, adding recycled flue gas, adding a recycled incompletely pyrolytically decomposed carbonaceous material, adding a recycled incompletely reformed carbonaceous material, adding at least one recycled contaminant, adding at least some select product gas, adding at least some wet product gas, adding at least some dry select product gas, adding at least some recycled select product gas, varying a process retention time, varying a process flow rate, varying a process flow turbulence, varying a process flow cavitation, varying a selectively applied heat distribution among multiple reformation coils, varying a temperature gradient in a temperature varied environment, varying a liquefaction zone in a temperature varied environment, selectively separating a carbonaceously reformed material, and the like. In some embodiments, these parameters may be process determinative in that their adjustment may affect and therefore perhaps determine the outcome of solid carbonaceous materials processing in the gasifier system.

Moreover, such dynamic adjustments may be effected at any suitable point of a gasifier process flow path with an appropriate input, including perhaps at a pretreatment area, at a pyrolysis chamber, at a multiple coil carbonaceous reformation vessel, at a select product gas components scrubber, and the like, perhaps even as may be embodied in some embodiments in a modular section of such a gasifier system. Additionally consistent with the dynamic character of such adjustments, the adjustments perhaps may be automatically effected, perhaps such as by computer control. Such dynamic adjustments may permit fast response time implementation of the adjustments, perhaps in times as little as less than 0.5 seconds, less than 1 second, less than 2 seconds, less than 3 seconds, less than 4 seconds, less than 5 seconds, less than 10 seconds, less than 15 seconds, less than 30 seconds, less than 45 seconds, less than 60 seconds, less than 90 seconds, and the like.

Various embodiments of course may involve effecting these dynamic adjustments in a variety of suitable modalities. For example, embodiments may include establishing an adjustable set point and periodically testing a process condition. Such a set point may involve carrying out processing to a set specification, such as a set time, temperature, pressure, or the like. In this manner, periodically testing a process condition, for example by measuring a processing time, temperature, pressure, or the like, may allow determination of processing conditions relative to the set point and appropriate dynamic adjustment if actual processing conditions are off. Further examples of suitable modalities may include evaluating a feedstock solids carbonaceous material, as with perhaps a feedstock evaluation system, for example by characteristics such as chemistry, particle size, hardness, density, and the like, and responsively dynamically adjusting process flow conditions accordingly. In some embodiments, responsive dynamic adjustments may involve affecting a select product gas, for example perhaps by increasing the purity, increasing BTU content, reducing contaminants, or creating a select product gas having one or more of these properties.

Embodiments may involve affirmatively establishing a stoichiometrically objectivistic chemic environment. This perhaps may involve establishing conditions, as within a pressurized environment to which a feedstock solids carbonaceous material may be subjected, having as an object the conversion of the feedstock solids carbonaceous material into a desired product, for example perhaps a desired select product gas. Such an environment of courses may be chemic, which may involve chemical interactions in which one or more components of the feedstock solids carbonaceous material may participate, or perhaps even simply non-chemical conditions related to such chemical interactions, for example such as temperature conditions, pressure conditions, phase conditions, or the like. Stoichiometric analysis may be utilized to affirmatively identify significant relationships among the components of the feedstock solids carbonaceous material and the desired product, for example such as quantity amounts of such components or perhaps chemical reaction sequences by which the feedstock solids carbonaceous material may be converted into the desired product. Where appropriate, stoichiometric compensation may be utilized to add or remove chemical components according to the identified relationships, for example perhaps to create an overall balance of components in proportion to the identified relationships. In various embodiments, stoichiometric compensation may be accomplished in a solid carbonaceous materials gasifier system via stoichiometrically objectivistic adjustment compensators, for example such as any of various suitable inputs, outputs, injectors, purges, dynamically adjustable process flow regulators, and the like, consistent with the principles described herein.

Some embodiments may involve stoichiometrically controlling carbon content in a manner significantly appropriate for a select product gas. This perhaps may involve applying the stoichiometric principles described herein to the relationship between the carbon content of a feedstock solids carbonaceous material and a carbon content of an object select product gas to be produced. For example, such stoichiometric applications may involve changing carbon quantities through various processing stages of a solid carbonaceous materials gasifier system. Processing may involve adding carbon content throughout a gasifier process flow path, such as to ensure sufficient quantities of carbon for complete interaction with other processing materials throughout the various processing states of the solid carbonaceous materials gasifier system. An object may be to achieve a target carbon content in a select product gas, for example perhaps according to the molar ratios of chemical reaction sequences in which the feedstock solids carbonaceous material may participate, or perhaps to achieve desired molar ratios of carbon to other chemical components of the object select product gas. Of course, this may be merely one example as to how carbon content may be stoichiometrically controlled, and should not be construed to limit the manner in which stoichiometric control may be applied to carbon content consistent with the principles described herein. Additional examples of controlling carbon content may include adding carbon, adding carbon monoxide, adding flue gas, adding pressurized flue gas, adding preheated flue gas, adding an incompletely pyrolytically decomposed carbonaceous material, adding an incompletely reformed carbonaceous material, adding at least some select product gas, adding at least some wet select product gas, and adding at least some dry select product gas. Moreover, a stoichiometrically objectivistic adjustment compensator in various embodiments of course may include a stoichiometrically objectivistic carbon adjustment compensator.

Affirmatively establishing a stoichiometrically objectivistic chemic environment in some embodiments perhaps may involve simply varying an input feedstock solids carbonaceous material, perhaps as described elsewhere herein. Similarly, such establishing perhaps may involve simply varying an output select product gas, as in perhaps varying the select product gas qualities perhaps described elsewhere herein. Variations of input and output in this manner of course may vary the relationships among the input and output materials, perhaps creating suitable opportunity for application of the stoichiometric principles discussed herein.
In some embodiments, affirmatively establishing a stoichiometrically objectivistic chemic environment may involve selecting a product gas to output, evaluating a feedstock solids carbonaceous material input, and determining a chemical reaction sequence appropriate to yield the select product gas from the feedstock solids carbonaceous material. Evaluating a feedstock solids carbonaceous material of course may employ a stoichiometric evaluation, for example such as identifying proportions, quantities, and chemistry of constituent components of the feedstock solid carbonaceous material, perhaps even as may be in relation to possible chemical reaction sequences appropriate to yield the select product gas. A suitable evaluation system may be employed, for example such as a chemistry sensor, a temperature sensor, a pressure sensor, a materials composition sensor, a carbon monoxide sensor, a carbon dioxide sensor, a hydrogen sensor, a nitrogen sensor, a gas chromatograph, a mass spectrometer, or the like. Moreover, embodiments further may involve supplying chemical reactants on a

stoichiometric basis, for example perhaps as in sufficient to satisfy the molar ratios of a chemical reaction sequence, sufficient to substantially completely chemically react the feedstock solids carbonaceous material, sufficient to produce a high output of select product gas, sufficient to temporally accelerate said chemical reaction sequence, or perhaps to effect other stoichiometrically objectivistic considerations. Supply of such chemical reactants of course may be effected with an appropriate stoichiometrically objectivistic chemical reactant input, for example perhaps a molar ratio input, a feedstock conversion input, a high output select product gas input, a catalyst input, or the like.

A flue gas in various embodiments perhaps may be utilized to affirmatively establish a stoichiometrically objectivistic chemic environment. For example, interaction of the flue gas with the chemic environment may create stoichiometrically objectivistic conditions, for example as wherein carbon content within a flue gas may contribute to stoichiometrically adjusting carbon levels within the chemic environment. Of course, this example simply may be illustrative of the stoichiometric properties of flue gas, and a flue gas may facilitate affirmative establishment of a stoichiometrically objectivistic chemic environment in other manners. Moreover, the modalities by which such flue gas may be stoichiometrically utilized may be consistent with principles described elsewhere herein. For example, a flue gas may be pressurized, perhaps to at least 80 psi. A flue gas may be preheated, perhaps to temperatures appropriate for a given processing stage such as at least 125° F., at least 135° F., at least 300° F., at least 600° F., or at least 1,640° F. A flue gas may be recycled, perhaps including recycling to a pretreatment area, recycling to a pyrolysis chamber, recycling to a multiple coil carbonaceous reformation vessel, recycling to a preliminary reformation coil of a multiple coil carbonaceous reformation vessel, recycling to a secondary reformation coil of a multiple coil carbonaceous reformation vessel, or recycling to a tertiary coil of a multiple coil carbonaceous reformation vessel. Moreover, the stoichiometric use of a flue gas may be considered to affect at least one process determinative parameter, perhaps as described elsewhere herein, perhaps such as by raising a temperature, maintaining a pressure, raising a pressure, chemically reacting, temporally accelerating a chemical reaction sequence, displacing at least some oxygen content from a feedstock solids carbonaceous material, displacing at least some water content from a feedstock solids carbonaceous material, affirmatively establishing a stoichiometrically objectivistic chemic environment for said feedstock solids carbonaceous material, and stoichiometrically controlling carbon content. Of course, the stoichiometric use of a flue gas may be effected by a suitable flue gas injector, consistent with the principles described herein.

In various embodiments, affirmatively establishing a stoichiometrically objectivistic chemic environment may include adding process beneficial materials and purging process superfluous materials. Adding process beneficial materials perhaps may simply involve adding materials to a process environment tending to benefit stoichiometric conditions, for example such as supplying materials to balance quantities in proportion to the molar ratios of a chemical reaction sequence or perhaps adding materials to induce or catalyze such chemical reaction sequences. Examples of process beneficial materials may include but may not be limited to carbon, hydrogen, carbon monoxide, water, preheated water, a negatively electrostatically enhanced water species, steam, negatively electrostatically enhanced steam, select product gas, wet select product gas, and dry select product gas. Similarly, purging process superfluous materials perhaps may simply involve removing materials superfluous, or perhaps even deleterious, to stoichiometric conditions, perhaps such as contaminants or even excesses of process materials that perhaps may be better utilized through recycling. Examples of purging process superfluous materials may include but may not be limited to purging oxygen, purging nitrogen, or perhaps even oxidizing metals and electrostatically attracting such oxidized metals. Of course, such adding and purging may be accomplished by any suitable input or purge consistent with the principles described herein.

Some embodiments may involve affirmatively establishing a stoichiometrically objectivistic chemic environment by using recycling, perhaps as described elsewhere herein. The stoichiometric principles in such embodiments may be the same as have been described, with perhaps utilized materials simply being recycled materials appropriately returned from various areas of a solid carbonaceous materials gasifier system.

Affirmatively establishing a stoichiometrically objectivistic chemic environment in certain embodiments may include sensing at least one process conditions and dynamically adjusting at least one process determinative parameter, perhaps as described elsewhere herein. Such establishing in some embodiments also may include evaluating a feedstock solids carbonaceous material and responsively dynamically adjusting at least one process determinative parameter, again perhaps as described elsewhere herein. In some embodiments, affirmatively establishing a stoichiometrically objectivistic chemic environment may involve removing water from a feedstock solids carbonaceous material at a water critical pass through, which perhaps may be a critical temperature and pressure for a given feedstock solids carbonaceous material at which water may pass out of the feedstock.

Certain embodiments may affirmatively establish a stoichiometrically objectivistic chemic environment in multiple stages. For example, such establishing may involve preheating a feedstock solids carbonaceous material, controlling oxygen content within the feedstock, as perhaps with an oxygen displacement system, and pyrolytically decomposing the feedstock solids carbonaceous material. Of course, this example may be merely illustrative of how a stoichiometrically objectivistic chemic environment may be established in multiple stages, and should not be construed to limit the manner in which such multiple stage establishment may be effected.

Various embodiments may involve affecting processing within a solid carbonaceous materials gasifier system with negatively electrostatically enhanced water species. For example, embodiments may include injecting negatively electrostatically enhanced water species into a gasifier process flow path, or perhaps even gasifier system components through which the gasifier process flow path is routed, perhaps by using a negatively electrostatically enhanced water species injector, routing a gasifier process flow path by a negatively electrostatically enhanced water species injector, and the like. The injection of a negatively electrostatically enhanced water species in such a manner perhaps may bring it into contact with carbonaceous materials entrained in a gasifier process flow path, including for example perhaps at a pretreatment area, a pyrolysis chamber, a multiple coil carbonaceous reformation vessel, a select product gas components scrubber, and the like.

In some embodiments, a negatively electrostatically enhanced water species may include an aqueous solution having a net negative charge, as perhaps having a negatively charged species content exceeding a contaminant background demand for the negatively charged species content. Examples of a negatively electrostatically enhanced water species in various embodiments may include an aqueous solution containing saturated hydrogen peroxide and negatively charged oxygen, an aqueous solution containing saturated hydrogen peroxide and singlet molecular oxygen, an aqueous solution containing saturated hydrogen peroxide and hydroxide, an aqueous solution containing saturated hydrogen peroxide and hydroxide radicals, an aqueous solution containing long-chain negatively charged oxygen species, a peroxyl activated aqueous solution, a nitroxyl activated aqueous solution, an oxygenated aqueous solution, an ionized oxygen vapor aqueous solution, and the like.

A negatively electrostatically enhanced water species in some embodiments perhaps may be preheated. Of course, preheating may be accomplished in any suitable manner consistent with the principles described herein, for example perhaps using a suitable preheater, perhaps such as a combustive burner or electric heater. In certain embodiments, a preheater for a negatively electrostatically enhanced water species perhaps may be a gasifier system process enclosure, such as perhaps a pyrolysis chamber enclosure, a multiple coil carbonaceous reformation vessel enclosure, or perhaps even a box furnace enclosure (**26**) (FIGURE 3.3.6.2. ; 3.3.6.3; 3.3.6.**14**; 3.3.6.**15**). Moreover, preheating a negatively electrostatically enhanced water species of course may generate steam, perhaps negatively electrostatically enhanced steam.

The manner in which a negatively electrostatically enhanced water species may affect processing within a solid carbonaceous materials gasifier system may be selected to achieve a desired result, for example perhaps to increase the purity of a select product gas, increase the BTU value of a select product gas, minimize contaminants in a select product gas, and the like. Such desired results may be considered to be, for example, injection products following the injection of a negatively electrostatically enhanced water species into a gasifier process flow path. Moreover, the use of a negatively electrostatically enhanced water species in this way perhaps even may be considered as one example of dynamically adjusting a process determinative parameter. For example, affecting processing perhaps may involve chemically reacting a negatively electrostatically enhanced water species, as perhaps with carbonaceous materials entrained in a gasifier process flow path. In such embodiments, the negatively electrostatically enhanced water species simply may be chemical reactant participating one or more chemical reaction sequences with the carbonaceous material, for example as to perhaps produce hydrogen select product gas components, produce carbon select product gas components, decrease hydrocarbon contaminants, increase carbon monoxide, increase hydrogen gas, and the like. Moreover, utilizing a negatively electrostatically enhanced water species as a chemical reactant perhaps may involve using it as catalyst, for example perhaps to temporally accelerate one or more chemical reaction sequences, or perhaps even to maximize the yield of one or more chemical reaction sequences. In some embodiments, such uses of a negatively electrostatically enhanced water species even perhaps may be part of affirmatively establishing a stoichiometrically objectivistic chemic environment and stoichiometrically controlling carbon content. Some embodiments may involve coactively utilizing a negatively electrostatically enhanced water species with other process materials, for example perhaps injecting a negatively electrostatically enhanced coactively with a flue gas.

Accordingly, negatively electrostatically enhanced water species may be use in a variety of processing application within a solid carbonaceous materials gasifier system. In embodiments having specific input feedstock solids carbonaceous materials chemistry, adjustable volumes of selected negatively electrostatically enhanced water species may be provided, for example such as more reactive ionized oxygen water, and perhaps may be injected and perhaps vapor released into a gasifier process flow path, as perhaps into one or more carbonaceous reformation coils of a multiple coil carbonaceous reformation vessel. This perhaps may also cause additional thermal steam vapor-cavitation turbulence reactions. The presence of a negatively electrostatically enhanced water species in the gasifier process flow path may provide much faster and more complete carbon conversion and steam reformation reactions to occur, for example such as within a pyrolysis chamber. Additionally, embodiments may have the capability to dynamically adjust process determinative parameters that may achieve a generation of optimum select product gas production energy ratios, decrease of CO_2 contamination, and increase or adjustment of desired higher energy output ratios of hydrogen and carbon monoxide, perhaps including the capability of process adjustments to yield higher output percentage fractions of methane content.

Moreover, negatively electrostatically enhanced water species may be recycled, perhaps to achieve nearly 100% recycling, as perhaps in a closed loop process within a solid carbonaceous materials gasifier system, and as to perhaps even exceed an environmental standard for recycling such a negatively electrostatically enhanced water species. In various embodiments, such recycled negatively electrostatically enhanced water species may be a recovered contaminant solubilization substance from a select product gas components scrubber. Through recycling, negatively electrostatically enhanced water species, such as perhaps ionized and perhaps peroxide saturated water, may be constantly provided to meet various process water control volume requirements within the solid carbonaceous materials gasifier system. For example, recycle uses of negatively electrostatically enhanced water species may include recycling to a pretreatment area, recycling to a pyrolysis chamber, recycling to a multiple coil carbonaceous reformation vessel, solubilizing a flue gas in a recycled negatively electrostatically enhanced water species, re-solubilizing at least one contaminant in a recycled negatively electrostatically enhanced water species, regenerating a negatively electrostatically enhanced water species, and generating steam from a negatively electrostatically enhanced water species.

Within the select product gas components scrubber, accelerated oxidizing and reducing negatively electrostatically enhanced water species recycle applications, perhaps as in-situ chemistry applications, along with chilled water condensing, perhaps may be applied which may provide for the isolation of items such as soluble tar, phenols, organic hydrocarbon vapors, particulate contaminants, and perhaps even soluble CO_2 and sulfur removals from various select product gas components, perhaps to produce a scrubbed select product gas. Recycled negatively electrostatically enhanced water species, as perhaps from a select product gas components scrubber, also may be used to scrub flue gas to maintain flue exhaust gas environmental air quality at or near zero discharge compliance, whenever flue gas may be discharged into the atmosphere.

A negatively electrostatically enhanced water species may be generated in various embodiments perhaps by a negatively electrostatically enhanced water species generation unit. Such a unit perhaps even may be integrated into a solid carbonaceous materials gasifier system, such as perhaps to permit on-site generation of negatively electrostatically enhanced water species and direct communication with a gasifier process flow path. For example, such a unit may be joined to a negatively electrostatically enhanced water species injector of a select product gas components scrubber. In embodiments, an initial generation of perhaps ionized oxygen vapors may take place within a negatively electrostatically enhanced water species generation unit, perhaps a gas ionization cylindrical system (**31**) such as shown in FIGURE 3.3.6.2. ; 3.3.6.3; 3.3.6.**11**; 3.3.6.**12**; 3.3.6.**17**. This may provide an efficient and perhaps high rate production of reactive and activated oxygen and ionized vapors. Such a unit in some embodiments may be a VIP™ vapor ion plasma generator, although such should use not to be taken to limit the inventive technology only to such embodiments. The use of a negatively electrostatically enhanced water species generation unit, again perhaps such as a VIP™, may refer to the production of ionized oxygen, associated peroxyl vapor gas ions, or the like. Such a negatively electrostatically enhanced water species generation unit may provide an efficient contaminant solubilization substance treatment unit. The components perhaps may be optimized to generate a plethora of highly reactive singlet oxygen species from oxygen in air. Such may occur under circumstances also encouraging secondary recombination with water, perhaps water vapor or steam vapor, such as to perhaps produce additional hydroxide and hydrogen peroxide gas vapor ions. In various embodiments, such as shown in FIGURE 3.3.6.2. 0 & 11, a negatively electrostatically enhanced water species generation unit may include, but may not require, elements as follows:

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    - element (**84**) LECTRON Power Supply Module
    - element (**85**) LECTRON "Plasma (Variable) Emission" Generator
    - element (**86**) (Air-Cooled) Aluminum "Spectral-Physics" Ionization Reactor
    - element (**87**) Primary Electronic power Supply Module
    - element (**88**) AIR-INTAKE (1.5″ Wide "Ring" Intake Air Filter (Atmospheric Nitrogen/Oxygen Air as the Ambient Treatment Source)
    - element (**89**) VIP™ Generated Vapor Ion (Out-Take) Delivery Port
    - element (**90**) O_2/O_2/0-0/e/OH Gas Vapor Ions (also generates H_2O_2 & Intermediate "Reaction By-Products" of Above)
    - element (**91**) Pump Injection ("Vortex Eduction") Into Contaminated Water Flow
    - element (**92**) 45 degree Return Line Rotation
    - element (**93**) Recirculation Flow Scrubber (Vapor Spray) "Ionized H2O" contact tank
    - element (**94**) 3″ Dia. Pipe Flange Connection
    - element (**95**) 3″ Cross
    - element (**96**) 3″×2″ Reducing Tee
    - element (**97**) 3″ Valve
    - element (**98**) Drain
    - element (**99**) (Optimal) Dual System Treatment Modules
    - element (**100**) Flow to Process Treatment "Entrained-Flow Gasifier" Equipment

- element (**101**) 7.5 H.P. Venturi Injector Pumps (#316 Stainless Steel Construction)
- element (**102**) (4) VIP™ Hi-Intensity "Ionized Oxygen" Generators
- element (**103**) (4) Venturi Injectors—All 1″ Thread Connections
- element (**104**) 1″ Dia. Stainless Steel (Each Venturi) Return Piping

The generation of negatively electrostatically enhanced water species may involve the use of singlet oxygen. This species of ionized oxygen may be referred to in academic and published literature as the superoxide ion. Superoxide vapor ions perhaps may be employed since they may be capable of strong oxidation or reduction reactions. In embodiments, the superoxide ion may be produced in conjunction with a solid carbonaceous materials gasifier system perhaps to generate negatively electrostatically enhanced water species, for example perhaps by combining a singlet oxygen species with water and generating long-chain negatively charged oxygen species, hydroxide, hydrogen peroxide, peroxyl, or the like. Moreover, such use of singlet oxygen may produce multiple beneficial processing effects. For example, negatively electrostatically enhanced water species produced from such singlet oxygen may be utilized in carbonaceous reformation, as perhaps in thermal conversion, steam reformation, devolatilization and the like, perhaps within one or more reformation coils of a multiple coil carbonaceous reformation vessel. Further examples may include the release of negatively electrostatically enhanced water species, perhaps HO_2^- peroxyl scavenger and highly reactive steam vapor ions, within and throughout a multiple coil carbonaceous reformation vessel in certain embodiments.

Table 2 illustrates what may be representative of some of the major chemical reaction sequences whereby various negative electrostatic enhancement species, perhaps for use in generating a negatively electrostatically enhanced water species and perhaps including singlet molecular oxygen ions, may be formed. Of course these are merely illustrative of such chemical reaction sequences and should not be construed to limit the inventive technology thereby. Table 2 may show a reaction of atmospheric oxygen, under the influence of short-wavelength ultraviolet energy ("UV") and a magnetic field (referenced by the symbols "MAG. E") as it may form a polarized or magnetic oxygen molecule, and thence may dissociate into singlet molecular oxygen ion species (also known as Superoxide Ions), which may be highly reactive. Table 2 also may show the formation of ozone, which in itself may be extremely reactive, and which also may dissociate to form singlet molecular oxygen ions. Table 2 also may show that the singlet molecular oxygen gas may further react with water vapor and may form hydrogen peroxide and perhaps hydroxide radicals. As illustrated by Table 2, the ionized oxygen may also react to form various combinations of hydrogen peroxide and/or hydroxide in water.

Table 2

NOTE:

EXCESS SINGLET & CHAINED SINGLET OXYGEN IONS REMAIN SATURATED IN H_2O, PROVIDING A RESIDUAL OF OXIDIZING & COAGULATIVE REACTION AGENTS.

VIP ™ = Vapor Ion Plasma

Various embodiments may involve producing a flue gas within a solid carbonaceous materials gasifier system, for example perhaps within a flue gas generation zone of the gasifier system. Such a flue gas generation zone may include for example a gasifier system process enclosure, perhaps as wherein a combustive burner may produce flue gas and may be enclosed within a combustive heat enclosure to heat part of a gasifier process flow path. Moreover, such produced flue gas in embodiments may be recycled to other areas of the gasifier system, perhaps such as to a pretreatment area, a pyrolysis chamber, a multiple coil carbonaceous reformation vessel, a preliminary reformation coil of a multiple coil carbonaceous reformation vessel, a secondary reformation coil of a carbonaceous reformation vessel, a tertiary reformation coil of a carbonaceous reformation vessel, or the like. Such recycling may involve routing recycled flue gas via a flue gas recycle path appended to the flue gas generation zone, perhaps to a flue gas recycle input of a gasifier process flow path, wherein the recycled flue gas perhaps may be injected into the gasifier process flow path as with a flue gas injector.

Recycled flue gas of course may be used in any appropriate manner consistent with the principles described herein, such as perhaps to affect a process determinative parameter of the gasifier system. For example, affecting a process determinative parameter may include raising a temperature, wherein a flue gas injector may be configured as a heater. Affecting a process determinative parameter also may include maintaining or raising a pressure, in which a flue gas injector may be configured as a pressure system. Affecting a process determinative parameter further may include chemically reacting a flue gas or temporally accelerating a chemical reaction sequence with a flue gas, in which a flue gas injector may be configured as a chemical reactant injector or perhaps even a catalyst injector as appropriate. Affecting a process determinative parameter also may include displacing oxygen content or water content from a feedstock solids carbonaceous material, in which a flue gas injector may be configured as an oxygen displacement system or a water displacement system, respectively. Affecting a process determinative parameter also may involve affirmatively establishing a stoichiometrically objectivistic chemic environment and stoichiometrically controlling carbon content, in which a flue gas injector may be configured as a stoichiometrically objectivistic carbon compensator. Moreover, pressurizing a flue gas may be for example perhaps to at least 80 psi, and preheating a flue gas may be for example to at least 125° F., at least 135° F., at least 300° F., at least 600° F., or even at least 1,640° F.

Various embodiments may involve selectively adjusting a process flow rate through a gasifier process flow path, for example perhaps with a selectively adjustable flow rate regulator. Adjusting such a process flow rate for example may include adjusting the flow characteristics of carbonaceous materials entrained in the gasifier process flow path. One example in various embodiments may involve regulating a pressure to velocity ratio for a process flow through a multiple coil carbonaceous reformation vessel, such as maintaining a pressure of at least 80 psi, maintaining a flow rate of at least 5,000 feet per minute, or perhaps maintaining a Reynolds Number value of at least 20,000. Another example in various embodiments may involve dominatively pyrolytically decomposing a feedstock solids carbonaceous material and acceleratedly carbonaceously reforming the dominatively pyrolytically decomposed feedstock solids carbonaceous material, for example as wherein the feedstock solid carbonaceous material may be retained within a pyrolysis chamber for greater than about 4 minutes, and wherein the pyrolytically decomposed carbonaceous material may be carbonaceously reformed from about 4 seconds to about 10 seconds.

In some embodiments, selectively adjusting a process flow rate may be accomplished with a venturi injector, perhaps to regulate a process flow rate. A venturi injector perhaps may regulate a process flow by utilizing Bernoulli effects achieved through a tube of varied constriction, perhaps configured in the form of a venturi. In some embodiments, a venturi injector (**17**) (FIGURE 3.3.6.2. ; 3.3.6.3; 3.3.6.9; 3.3.6.10; 3.3.6.**15**) may provide a cavitation or other high-mix turbulence unit, perhaps point source, that may contribute to increasing higher efficiency steam reformation contact, perhaps with pass-through carbon particulate material. The venturi injector design (**17**) (FIGURE 3.3.6.2. ; 3.3.6.3) illustrated in FIG. 8; **9** may include an input, perhaps a steam input, a negatively electrostatically enhanced water species input, or a select product gas input, such as at an injection port (**51**) (FIGURE 3.3.6.2. ; 3.3.6.3), whereby complete rotational flow turbulent mixing of an input substance may be provided. For example, reformation coil reaction rates, perhaps as in a multiple coil carbonaceous reformation vessel, may be accelerated with the reactants mixing or cavitationally impinging upon one another. Substantial mixing, including perhaps greater than 90% mix-atomization turbulence and perhaps even near 100% mix-atomization turbulence, perhaps may also occur in the process flow passing through the venturi injector throat body. Also, the exit port body of the venturi injector perhaps may be fitted with a stop-block ring, which may create an additional zone of intense and secondary turbulence, perhaps by impeding the process flow.

An injection port (**51**) may be disposed on a venturi injector (**17**) in any suitable configuration, for example perhaps tangentially positioned at the throat of the venturi injector (**17**). Moreover, an injection port (**51**) of course may be configured to inject any suitable substance into the venturi injector (**17**), and of course consequently venturi inject the substance into a gasifier process flow path, consistent with the principles described herein. For example, an injection port (**51**) in various embodiments may include a flue gas injection port, a pressurized flue gas injection port, a preheated flue gas injection port, a recycled flue gas injection port, a water injection port, a preheated water injection port, a recycled water injection port, a negatively electrostatically enhanced water species injection port, a preheated negatively electrostatically enhanced water species injection port, a recycled negatively electrostatically enhanced water species injection port, a steam injection port, a recycled steam injection port, a negatively electrostatically enhanced steam injection port, a recycled negatively electrostatically enhanced steam injection port, a select product gas injection port, a wet select product gas injection port, a dry select product gas injection port, and a recycled select product gas injection port.

Utilization of a venturi injector (**17**) (FIGURE 3.3.6.2. ; 3.3.6.3; 3.3.6.9; 3.3.6.10; 3.3.6.**15**) may be provided at any suitable location or locations of a gasifier process flow path to regulate flow rates or characteristics, perhaps such as shown for some embodiments in FIGS. 3.3.6.3; 3.3.6.9; 3.3.6.10; 3.3.6.**11**. These may be connected with one unit per each of the reformation coils of a multiple coil carbonaceous reformation vessel, as perhaps may be installed in a downward process flow side of each reformation coil, or in other gasifier process flow path control locations. Alternate venturi injector positions perhaps may be provided as additional dynamically adjustable process determinative parameters. The position of the venturi injectors may be altered to provide additional high levels of process flow efficiencies, such as perhaps when venturi injectors (**17**) may be connected one each on the outlet side of each of the cyclones (**20**) (FIGURE. 3.3.6.2; 3.3.6.3; 3.3.6.**15**). The dynamically adjustable process determinative parameters that may define the specific, and perhaps optimal, number of venturi injectors (**17**), and that may be installed within the overall length of a reformation coil-cyclone closed process loop, may also be a function of identifying the available energy and carbon content of the input feedstock solids carbonaceous material. In some embodiments, for example, it may be that no more than four venturi injectors (**17**) may need to be installed, perhaps because total pressure drop, or head losses, may increase proportionally. A reformation coil near minimum pressure of 80 psi to 100 psi, along with a high velocity operating throughput process flow, of perhaps a minimum velocity of about 5,000 feet per minute through the entire reformation coil-cyclone assembly, perhaps may need to be maintained, as the pressure to velocity ratio may represent an operational control variable in some embodiments. The exact configuration and number of installed venturi injectors (**17**) perhaps may be determined accordingly, so that the reformation coil pressure and process flow velocities perhaps may be constantly maintained at a desired level.

In some embodiments, a venturi injector (**17**) may include an injection port, through which the provision of side-stream negatively electrostatically enhanced water species injection, such as perhaps hydrogen peroxide saturated water, may induce an excited steam state reaction activity perhaps throughout the length of the reformation coils of a multiple coil carbonaceous reformation vessel. It perhaps may also thereby accelerate carbon dioxide destruction reactions and perhaps may even substantially increase carbon monoxide and hydrogen generation. This may be understood by the following reaction equation sequence, Table 3:

Table 3

The scientific basis for this CO_2 depletion, as may occur within the gasifier process flow routed through the reformation coils of a multiple coil carbonaceous reformation vessel, may be contingent upon the generation of singlet molecular oxygen ($O_2^{\ -}$), such as might be produced for combination with water to produce a negatively electrostatically enhanced water species, such as hydrogen peroxide saturated water. This may be as shown in Table 3. When singlet oxygen, perhaps peroxide saturated water, may be injected into the reformation coils (**19**) (FIGURE 3.3.6.2. ; 3.3.6.3; 3.3.6.4; 3.3.6.5; 3.3.6.**15**) of a multiple coil carbonaceous reformation vessel, it may convert to a released and perhaps excited state $HO_2^{\ -}$ peroxyl ion, which may react with the gasifier process flow stream. Embodiments may similarly produce a $HO_2^{\ -}$ vapor ion, and this may be similarly injected into the reformation process.

In certain embodiments, flow through three or four connected venturi injectors (**17**) (FIGURE 3.3.6.2. ; 3.3.6.3; 3.3.6.9; 3.3.6.10; 3.3.6.**15**) may range at a pressure from between about 80 psi to about 100 psi, and the pressure may be maintained throughout areas such as the reformation coils of a multiple coil carbonaceous reformation vessel (**19**) (FIGURE 3.3.6.2. ; 3.3.6.3; 3.3.6.4; 3.3.6.5; 3.3.6.**15**), perhaps through associated connected cyclones such as cyclones (**20**), (**22**), and (**23**) respectively (FIGURE 3.3.6.2. ; 3.3.6.3; 3.3.6.4; 3.3.6.5; 3.3.6.**15**). In embodiments, this pressure may perhaps overcome the total accumulated back-pressure or the sum of the head losses within a multiple coil carbonaceous reformation vessel, or perhaps be able to sustain higher and perhaps optimum gasifier process velocities such as not less than about 5,000 feet per minute throughout the vessel. Perhaps even at, or above, an appropriate velocity, high energy Reynolds Numbers of 20,000+ may be achieved to perhaps ensure that tars, phenols, hydrocarbons and other debris inorganics or particulates may not plate-out or begin to agglomerate within the reformation coil components. Carbonaceous materials, perhaps particulates or atomized char organic particles, may also thoroughly react in the gasifier process flow, as perhaps with high pressure steam generated such as within the reformation coils, perhaps with water carry-through or perhaps a negatively electrostatically enhanced water species being the source for the steam. Embodiments may also produce highly efficient carbon shift and conversion reactions. In embodiments, total reformation time within a multiple coil carbonaceous reformation vessel, perhaps including cyclone retention times, may be engineered to be process maintained, perhaps even in the 4 second to 10 second range, and perhaps as dependent upon the daily tonnage of raw feedstock solids carbonaceous materials throughput that may be desired. Computerized automation, perhaps coupled with continuous read mass spectrometer and gas chromatograph online instrumentation, may be included to provide control functions that may readily determine dynamic adjustments to perhaps optimize process determinative parameters, perhaps such as process flow velocities, process flow pressures, and/or perhaps Reynolds Number operational set-points. This control procedure perhaps may ensure that clean select product gas, perhaps with minimal CO_2 and hydrocarbon residual contamination, may be produced at high BTU energy value. Controlled molar ratios of select product gas components, for example such as at least 1:1 molar ratios of carbon monoxide to hydrogen and perhaps up to approximately 20:1 molar ratios of carbon monoxide to hydrogen, may be produced in the select product gas and perhaps may be consistently held, perhaps with fractional or even no substantial carbon dioxide content, nitrogen oxide content, or sulfur oxide content contaminants present in the generated select product gas.

Using the principles described herein, embodiments may involve creating a high energy content select product gas. For example, creating such a high energy content select product gas may involve increasing its BTU value. Processing steps tending to increase BTU value may be employed, perhaps in a manner to create a higher BTU value select product gas as compared to processing steps using conventional gasification techniques. Accordingly, embodiments may involve the production of a select product gas having a BTU value of at least 250 BTU per standard cubic foot, having a BTU value from about 250 BTU per standard cubic foot to about 750 BTU per standard cubic foot, having a BTU value from about 350 BTU per standard cubic foot to about 750 BTU per standard cubic foot, having a BTU value from about 450 BTU per standard cubic foot to about 750 BTU per standard cubic foot, having a BTU value from about 550 BTU per standard cubic foot to about 750 BTU per standard cubic foot, and having a BTU value from about 650 BTU per standard cubic foot to about 750 BTU per standard cubic foot. In various embodiments, varied inputs of feedstock solids carbonaceous materials may nevertheless result in consistent BTU values for produced select product gas, with perhaps the amount of produced select product gas varying in quantity proportion to the BTU value of the input feedstock carbonaceous material.

Moreover, creating a high energy content select product gas may involve increasing the purity of a select product gas. Again, processing steps tending to increase purity may be employed, perhaps in a manner to increase purity as compared to processing steps using conventional

gasification techniques. Purifying a select product gas may involve, for example, isolating or perhaps removing one or more contaminants. For example, purifying a select product gas in various embodiments may involve minimizing nitrogen oxide content of a select product gas, minimizing silicon oxide content of a select product gas, minimizing carbon dioxide content of a select product gas, minimizing sulfur content of a select product gas, minimizing organic vapor content of a select product gas, and minimizing metal content of a select product gas.
The processing steps used to create a high energy content select product gas may be as have been described herein, and for example may include but may not be limited to processing with a negatively electrostatically enhanced water species, processing with a recycled select product gas, processing with negatively electrostatically enhanced steam, processing with a flue gas, varying a process retention time, processing in at least a preliminary reformation coil and a secondary reformation coil, recycling an incompletely pyrolytically decomposed carbonaceous material, and recycling an incompletely reformed carbonaceous material.

Also using the principles described herein, embodiments may involve predetermining a desired select product gas for output. Such predetermining may involve consistently outputting a desired predetermined select product gas from varied input feedstock solids carbonaceous materials, as perhaps wherein one or more processing stages within a solid carbonaceous materials gasifier system may compensate for variations among input feedstock solids carbonaceous materials. For example, predetermining in various embodiments may involve affirmatively establishing a stoichiometrically objectivistic chemic environment, stoichiometrically controlling carbon content, dynamically adjusting at least one process determinative parameter within a solid carbonaceous materials gasifier system, or the like. Such adjustments perhaps may confer a high degree of control over the characteristics of a predetermined select product gas. For example, a predetermined select product gas in various embodiments may include a variable carbon monoxide content select product gas, a primarily carbon monoxide select product gas, a variable hydrogen content select product gas, a primarily hydrogen gas select product gas, a variable methane content select product gas, a primarily methane select product gas, a select product gas of primarily carbon monoxide and hydrogen gas and methane, a controlled molar ratio select product gas, a controlled molar ratio select product gas having a hydrogen gas to carbon monoxide molar ratio of from 1:1 up to 20:1 by volume, a controlled molar ratio select product gas having a hydrogen gas to carbon monoxide molar ratio of at least about 1:1, a controlled molar ratio select product gas having a hydrogen gas to carbon monoxide molar ratio of at least about 2:1, a controlled molar ratio select product gas having a hydrogen gas to carbon monoxide molar ratio of at least about 3:1, a controlled molar ratio select product gas having a hydrogen gas to carbon monoxide molar ratio of at least about 5:1, a controlled molar ratio select product gas having a hydrogen gas to carbon monoxide molar ratio of at least about 10:1, a controlled molar ratio select product gas having a hydrogen gas to carbon monoxide molar ratio from at least about 1:1 to about 20:1, a controlled molar ratio select product gas having a hydrogen gas to carbon monoxide molar ratio from at least about 2:1 to about 20:1, a controlled molar ratio select product gas having a hydrogen gas to carbon monoxide molar ratio from at least about 3:1 to about 20:1, a controlled molar ratio select product gas having a hydrogen gas to carbon monoxide molar ratio from at least about 5:1 to about 20:1, a controlled molar ratio select product gas having a hydrogen gas to carbon monoxide molar ratio from at least about 10:1 to about 20:1, a producer gas, and a synthesis gas. Moreover, a select product gas in various embodiments may include a base stock, as wherein the produced select product gas may be used as a basis for post-gasifier system applications, for example as stock for the production of additional substances. Accordingly, a select product gas in various embodiments perhaps may include a variable chemistry base stock, a liquid fuel base stock, a methanol base stock, an ethanol base stock, a refinery diesel base stock, a biodiesel base stock, a dimethyl-ether base stock, a mixed alcohols base stock, an electric power generation base stock, or a natural gas equivalent energy value base stock.

Further using the principles described herein, embodiments may involve producing a high yield select product gas, perhaps even exceeding a typical yield of conventional gasification processes for produced select product gas from a given input feedstock solids carbonaceous material. For example, such high yields may involve converting greater than about 95% of the feedstock mass of a feedstock solids carbonaceous material to select product gas, converting greater than about 97% of the feedstock mass of a feedstock solids carbonaceous material to select product gas, converting greater than about 98% of the feedstock mass of a feedstock solids carbonaceous material to select product gas, outputting at least about 30,000 standard cubic feet of select product gas per ton of feedstock solids carbonaceous material, or perhaps achieving a carbon conversion efficiency of between 75% and 95% of carbon content in a feedstock solids carbonaceous material converted to select product gas. Moreover, a high yield in certain embodiments may involve substantially exhausting a carbon content of an input feedstock solids carbonaceous material.

In some embodiments, the inventive technology described herein perhaps may be configured in a modular and compact form, perhaps that may provide an autonomous and uncomplicated select product gas generation technology that may allow for selected conditions operational capability and that may produce a very high purity and high energy select product gas from a variety of input feedstock solids carbonaceous materials, perhaps even virtually any type of organic biomass, coal input or other carbonaceous raw material. Of course, such modularity merely may be one aspect of the inventive technology, and should not be construed to limit the inventive technology only to modular embodiments. Predetermined adjustments in operating process retention times, gas velocity pressures, negatively electrostatically enhanced water species injection control rates, recycled select product gas injection parameters, and flue gas injection parameters may be included to further provide for the generated select product gas final output chemistry to be tuned, for example perhaps as may be related to producing large, perhaps uncontaminated volumes of secondary off-take commodities, such as liquid fuels, electricity generation, hydrogen gas, and the like. Set-point operational parameters may be included, such as progressive control of devolatilization temperature, adjustable gas velocity and reaction time, variable water, perhaps steam, negative electrostatic enhancement chemistry additions, or basic steam reformation operational energy balance capabilities. Environmental beyond-compliance discharge or perhaps even zero discharge may be maintained in some embodiments, perhaps with exhaust flue gases being internally recycled. In embodiments, a negatively electrostatically enhanced water species treatment system may be included to provide the possibility for a high percentage, or perhaps even 100%, recycle and reuse of highly purified water to be constantly returned back into the process. In embodiments, small volumes of process residual or system drain excess water may be relatively pure and perhaps may be flash evaporated with application of system excess heat, with perhaps no discharge to the environment. Further, applied negatively electrostatically enhanced water processes may be included perhaps to scrub and purify flue gas exhaust trace releases, including if and when applicable to meet relevant air quality emission control regulations. Embodiments even may provide one overall low maintenance and simple operation system design that may be economically feasible for a variety of given applications.

Some embodiments perhaps may provide an entrained flow select product gas generation system. In some embodiments, process parameters may allow many available and various kinds of carbonaceous wastes or commercial feedstock materials, such as wood waste, garbage, sewage solids, manure, agricultural or other environmental biomass, shredded rubber tires, coal, and the like, perhaps all to be processed perhaps through one basic platform design. In embodiments, energy may be released and recovered as a produced select product gas, perhaps containing high combustion ratios of adjustable content CO and H_2, perhaps along with secondary by-product generation of water, carbon dioxide, and light hydrocarbons that perhaps may be laced with volatile, but perhaps condensable, organic and inorganic additional, perhaps contaminant, compounds. Impurities perhaps may be removed within a secondary negative electrostatically enhanced water species scrubber section as well.

As an alternate to using coal as a commercially available feedstock material (e.g., a feedstock perhaps with consistent carbon conversion content), there may be a variety of non-coal biomass resources available, perhaps being widely and demographically dispersed. These may vary greatly in their heterogeneous chemical characteristics makeup. Embodiments of the inventive technology may provide a system application for an adjustable broad spectrum, perhaps even near universal select product gas generation process control design, and may further provide a perhaps operational, perhaps economic, perhaps efficient system that perhaps may be completely capable of processing nearly any type of input carbonaceous feedstock and generating high energy select product gas output. Embodiments of the inventive technology also may be capable of availability throughout the world marketplace, and may provide alternative select product gas availability to the world marketplace.

FIGURE 3.3.6.2. 3.3.6.9 through 3.3.6.23 show a portable or "pod" embodiment of the invention. As can be understood from the FIG. 18, this embodiment may include a pod or isolated reactor unit (**211**). This isolated reactor unit (**211**) may be surrounded by a refractory area (**212**). The refractory area (**212**) may include a sealed refractory shroud (**213**). A feed (**214**) may provide material to the isolated reactor unit (**211**) as shown. The material may then be acted upon in an upper pyrolysis deck (**215**) and perhaps subsequently a lower steam reformation deck (**220**). Each of these decks may actually be rotating carousel decks (**216**). These rotating carousel decks (**216**), may be aligned with a carousel drive shaft (**217**), which may be supported by an upper bearing support (**218**) and perhaps a bottom oil seal pivot bearing (**219**). The entire isolated reactor unit (**211**) may be surrounded at least partially by a flue gas chamber (**221**). For reasons discussed earlier, ionized water nozzles or injectors (**222**) may be included as well. Spend material may fall into an ash drop (**223**), which may pass through an air lock valve (**224**), an ash auger (**226**), and ultimately into an ash collection bin (**227**). The system may be driven by a gearbox drive (**225**).

To provide the input feed, and embodiment may include a feed section (**229**). The feed section (**229**) may provide material from a bunker pin or the like. Perhaps through multiple venturi injectors (**228**) that each permit an adequate amount of pressure increase. The feed section (**229**) may be surrounded by a gas shroud chamber (**230**). This gas shroud chamber (**230**), allows passage of flue or product gas, which may permit pre-heating a feedstock material. As shown, material may pass into a feed plenum (**231**), which may act as a separator (**232**) to separate a motive agent such as a gas or the like from the feed material. The feed plenum (**231**), may have an access (**233**) through which a motive agent or the like may pass in or out. As may be understood, in an instance where the motive agent is an agent such as flue gas, the excess gas may pass out of the access (**233**) and return to the system for recycling or reuse. Similarly, the system may include a shroud flue gas output (**235**), which may permit flue gas output shroud gas for return to the system or the like. This return may have various input locations, such as the venturi injectors or other locations.

Further, the "pod" embodiment shown may include a raw feedstock input (**237**) such as from a feedstock bin or the like. This feedstock input (**237**) can accept an external source of material for appropriate processing.

FIG. 21 shows a similar system in a more generic understanding. As one way providing compact processing, operations may include mechanically propelling at least one carbonaceous materials pyrolysis decomposition platform. This carbonaceous materials pyrolysis decomposition platform such as the upper pyrolysis deck (**215**). Operations may also include mechanically propelling at least one pyrolytically decomposed carbonaceous materials processor platform such as the lower steam reformation deck (**220**). These may be propelled by a mechanical gasifier drive system (**201**). In fact both the decks may be platforms and thus the system may include a mechanically propelled carbonaceous materials pyrolysis decomposition platform (**202**) and a mechanically propelled pyrolytically decomposed carbonaceous materials processor platform (**203**). In this fashion the system can be considered as having a plurality of environment differentiated mechanically propelled pyrolytically decomposed carbonaceous materials processor platforms.

It should be understood that the type of mechanical propulsion used can vary. In one embodiment, the system may include rotating platforms. As shown, there may be a rotating pyrolytically decomposed carbonaceous materials processor platform such as the upper pyrolysis deck (**215**), and a rotating a carbonaceous materials pyrolysis decomposition platform, such as the lower steam reformation deck (**220**). As may be understood, it may be advantageous for embodiments to have the rotations be horizontal rotations, that is, in a perpendicular to gravity. In addition, it may be advantageous to coordinate the rotation are other movements involved. In this way, the system may involve coordinated movement platforms or coordinatively mechanically propelling items for appropriate processing. These coordinated movements may be synchronous and may even be driven by a single drive. Thus, the system may include synchronous duality of movement platforms, driven by a single mechanical gasifier drive system. As can be appreciated, by singularly driving both platforms, only one drive system may be necessary. In addition, the platforms may rotate at identical rates for one type of coordinated processing.

Processed material may be subjected to different environments as it sequences through the reactor. These environments may be differentiated by any number of variables. As but some examples, the environments may be differentiated by process factor variable such as: a process material size factor, a process temperature factor, a process duration factor, a differentiated environment factor, a reactor electrostatic steam factor, a chemic environment factor, a water environment factor, a negative electrostatic charge water environment factor, a differentiated carbon content factor, a differentiated oxygen content factor, a differentiated flue gas content factor, a differentiated product gas factor, a recycled process material factor, among others. The platforms and even the generic processor can sequence and have different components as well. Processors may be: a variable temperature zone carbonaceous feedstock processor, a carbonaceous feedstock processor configured to establish a temperature from 125 degrees Fahrenheit to 135 degrees Fahrenheit, a carbonaceous feedstock processor configured to establish a temperature from 135 degrees Fahrenheit to 300 degrees Fahrenheit, a carbonaceous feedstock processor configured to establish a temperature from 300 degrees Fahrenheit to 1,000 degrees Fahrenheit, a carbonaceous feedstock processor configured to establish a temperature from 1,000 degrees Fahrenheit to 1,640 degrees Fahrenheit, and a carbonaceous feedstock processor configured to establish a temperature from 1,640 degrees Fahrenheit to 1,850 degrees Fahrenheit.

In one embodiment, the invention may include carousel platforms that may even simply rotate about a horizontal axis. Thus, the system may involve mechanically propelling a carbonaceous materials pyrolysis carousel, and even mechanically propelling a pyrolytically decomposed carbonaceous materials processor carousel. By configuring the carousels or carousel platforms at different levels, the system may include a tiered carousel (**204**). That tiered carousel (**204**), may involve carousel tiered platforms as shown. It may also involve coaxial and perhaps even vertical tiering. Thus there may be a coaxial carousel tiered drive system that acts to mechanically propel a tiered carousel and shown.

An important part of sequentially processing material can include transferring the material between different environments. This can occur through a process transfer that moves processed material between different environments. In the embodiment shown, this process transfer can include one or more fixed decomposed carbonaceous materials scrapers (**206**), as well as one or more dispersionary freefall transfers (**205**). By the dispersionary freefall transfer (**205**) material may gravimetrically fall from one level to the next. This can promote mixing and more complete processing. Thus, as carousel platforms rotate, the material on the platforms may be subjected to fixed element scraping, which can push the material off of the platform and cause it to fall onto the next processing platform.

In each of the reactor sections, it should be understood that additional platforms can be provided. For example, there can be a plurality of interstitial output coordinated platforms. More than one platform can be used in the pyrolysis processes such as so that the material is adequately decomposed or the like. Both the pyrolysis and reformation functions can have multiple platforms. For instance, as shown it can be understood that the system may include first and second pyrolysis environment process platforms, as well as first and second carbonaceous reformation environment process platforms. Each of these may include differentiated status such as differentiated pyrolytically decomposing, as well as differentiated reformation steps.

As can be understood from the figures, the "pod" concept can permit many advantages. As shown in FIGURE 3.3.6.2. 8 and 21 and discussed later, systems may be portable. In addition, environmental safety can be promoted by entirely encasing aspects of the system. Thus, by substantially sealingly wholly containing the reactor or the like, a more safe system can be provided. As shown, the sealed refractory shroud (**213**) may be configured to circumscribe and create a substantially sealed process chamber and a sealed burner chamber (**241**). Thus there can be a substantially wholly contained gasifier. This encasement may have thermal advantages and may be a substantially sealed circumscribing heat shield encasement that thermally encases aspects of the system. The sealed refractory shroud (**213**) and other components may create a thermal circumscribing heat shield encasement. This may surround the chamber, the platforms, the reactors, and the like. Operations performs may even include: sealably encased mechanically propelling, sealably encased pyrolytically decomposing, sealably encased carbonaceous reforming, encased processing, encased generating, encased recycling, and even generating a flue gas within an encased gasifier system, as but a few.

FIG. 22 shows a lower portion of a "pod" embodiment of the present invention. This may include a product synthesis gas combustion bottom burner (**241**) so that the increasing temperature is provided at a bottom location. This may aid in effecting a tiered heat distribution, where there is increasing temperature at lower levels. This can work in conjunction with the fact that processed material sequentially falls from one carousel to another and thus is sequentially treated to increasing temperatures.

In encased designs such as the "pod" system shown, the substantially sealed circumscribing heat shield encasement may have a variety of inputs and outputs (**242**). Among others, these may include a recirculatory water input (**243**) and a recirculatory water output (**244**) such as from and external, unencased, or perhaps even separate treatment system that operates for treating water, gas, material or the like. These systems may even be recirculatory and thus the system may operate for inputting recirculatory water and outputting recirculatory water from an encased environment. The outputs can be varied and may include: a negatively electrostatically enhanced water species processed select product gas output, a flue gas processed select product gas output, a varied retention time processed select product gas output, a select product gas processed in at least a preliminary reformation coil and a secondary reformation coil output, a select product gas processed with a recycled incompletely pyrolytically decomposed carbonaceous material output, and a select product gas processed with a recycled incompletely reformed carbonaceous material output, among others.

The input can also have ferried configurations. As shown, one type of input can include a pneumatic propellant system (**245**). This could use flue gas and be a flue gas propellant system, synthesis gas and be a product synthesis gas propellant system. As such either flue gas or synthesis gas might be used for propelling materials such as feedstock solids into the reactor environments. Thus the system may have a pneumatically propelled feedstock solids carbonaceous material input that may even pneumatically propel solids up into an areas such as the feed plenum. By pneumatically propelling the feedstock, the input may act as a dispersionary feedstock solids carbonaceous material input (**237**) that disperses a feedstock. It may also subject it to a gas, such as for oxygen depletion, pre-heating, or the like.

As shown by running the materials up an incline, the system may include an accretive feedstock energy system (**245**) through which the system may operate for feedstock energy accretively propelling of the feedstock. Thus the feedstock has higher energy (potential or kinetic) after input. This system may also be an accretive feedstock potential energy input system (**248**) that causes an increase in the potential energy so that the feedstock can fall down from one platform to another by gravity without needing additional energy or drive mechanisms. The embodiment shown involves an inclined feedstock solids carbonaceous material input (**249**) that drives the feedstock solids carbonaceous material up an incline. This incline may even be vertical if desired such as for space saving reasons or the like.

In the embodiment shown, the input is shown as a coaxial feed system (**250**). This type of the system can operate for coaxially feeding and coaxially propelling a feedstock in one path and something else in a perhaps surrounding path. In one embodiment in this may involve outer coaxially feeding a flue gas and inner coaxially feeding a feedstock solids. These may even be established in opposite coaxial flows so that one flows up and the other down, or one flows left and the other right. As shown there may be an inner feedstock pathway and an outer flue gas pathway. These two opposite flow direction pathways may serve to put feedstock in and to exit flue gas or the like. While at the same time pre-heating the material and providing a feedstock coaxial pre-heater system (**250**) that may precondition it for ultimate processing. In order to permit the pressure differential required from a feedstock, due to the higher pressure processing reactor, the system may include one or more continuous feed, pressure differential venturi injectors.

As mentioned earlier, it may be advantageous to utilize water, and perhaps even negative electrostatically enhanced water for processing. This may be through use of a recirculatory negatively electrostatically enhanced water species treatment system (**259**). There may be one or more negatively electrostatically enhanced water species injectors perhaps positioned adjacent at least one of the platforms so that the water or steam can appear in the process at the desired location. These injectors may even be sidewall negative electrostatically enhanced water species injectors (**253**) that are positioned along the sidewall such as that one carousel location. This sidewall may be an inner or outer sidewall. There may even be one or more driveshaft negative electrostatically enhanced water species injectors (**254**) that act to disburse water or steam from in the vicinity of the driveshaft. This can aid in providing steam at the inner and outer locations of the carousel environment. As shown in FIGURE 3.3.6.12, the entire water treatment process can be accomplished external to the encased area. There may even be at a trailer adjacent recirculatory negatively electrostatically enhanced water species treatment system (**259**) that would transport FIG. 3.3.6.12 water treatment system. It should be understood that although this is shown as attached on one trailer, such a system can be entirely separate and perhaps even on a separate trailer or otherwise. As such an embodiment could present a separately portable recirculatory negatively electrostatically enhanced water species treatment system. There could also be an adjacent treatment system such as shown in

FIG. 19 where the water treatment components are adjacent the processor and may be on one or either side.

As may be appreciated, it may be desirable to make a portable or at least movable system. This could be configured such as on a trailer base (**258**). In order to permit transportation of the largest possible system, designed include a disabling collapse element (**255**). Such an element could fold-down, detach, or separate elements or components to permit transporting the entire system. Embodiments may permit compactly transportive collapsing parts of the system and perhaps even collectively moving a substantial portion of the gasifier system. Once moved the collapsed portions may be reassembled thus re-establishing the system in an operative state. Various portions can be made collapsible. These could include: a repositionable carbonaceous feedstock input, a detachable carbonaceous feedstock input, a separable carbonaceous feedstock input, a collapsible inclined carbonaceous feedstock input, a collapsible inclined carbonaceous feedstock input, a collapsible feed plenum, and the like. As shown, one aspect that can facilitate as compacted design is possible, may include having an off center feedstock solids carbonaceous material input (**256**). Collapsing the system can include collapsing at least a portion of a recirculatory water system. This may occur by repositioning at least one water tank, by detaching at least a portion of a recirculatory system, by separating, collapsing, or otherwise reducing in size aspects of the water system.

Of course, it may be desirable to transport the system. This may occur on a trailer or perhaps even on a low center section trailer (**258**). Thus as shown, the processor may be positioned at least partially in a low center section of a trailer base. The entire system could be on one or more trailers. As shown a particularly compact system is configured to be put entirely on a single road transportable trailer. Thus an extremity of system on the trailer base may be collapsed to reduce at least one operable condition external dimension for transport. In this manner the system may be sized from both the perspectives of providing a large or a small system. These designs can be configured to be sized for process rates such as: at least about 25 tons per day, at least about 50 tons per day, at least about 100 tons per day, at least about 150 tons per day, at least about 200 tons per day, and at least about 250 tons per day up to about 500 tons per day.

As may be easily understood from the foregoing, the basic concepts of the present inventive technology may be embodied in a variety of ways. It may involve both select product gas generation techniques as well as devices to accomplish the appropriate select product gas generation. In this application, the select product gas generation techniques are disclosed as part of the results shown to be achieved by the various devices described and as steps which are inherent to utilization. They are simply the natural result of utilizing the devices as intended and described. In addition, while some devices are disclosed, it should be understood that these not only accomplish certain methods but also can be varied in a number of ways. Importantly, as to all of the foregoing, all of these facets should be understood to be encompassed by this disclosure.

The discussion included in this patent application is intended to serve as a basic description. The reader should be aware that the specific discussion may not explicitly describe all embodiments possible; many alternatives are implicit. It also may not fully explain the generic nature of the invention and may not explicitly show how each feature or element can actually be representative of a broader function or of a great variety of alternative or equivalent elements. Again, these are implicitly included in this disclosure. Where the invention is described in device-oriented terminology, each element of the device implicitly performs a function. Apparatus claims may not only be included for the device described, but also method or process claims may be included to address the functions the invention and each element performs. Neither the description nor the terminology is intended to limit the scope of the claims that will be included in any subsequent patent application.

It should also be understood that a variety of changes may be made without departing from the essence of the inventive technology. Such changes are also implicitly included in the description. They still fall within the scope of this inventive technology. A broad disclosure encompassing both the explicit embodiment(s) shown, the great variety of implicit alternative embodiments, and the broad methods or processes and the like are encompassed by this disclosure and may be relied upon when drafting the claims for any subsequent patent application. It should be understood that such language changes and broader or more detailed claiming may be accomplished at a later date (such as by any required deadline) or in the event the applicant subsequently seeks a patent filing based on this filing. With this understanding, the reader should be aware that this disclosure is to be understood to support any subsequently filed patent application that may seek examination of as broad a base of claims as deemed within the applicant's right and may be designed to yield a patent covering numerous aspects of the invention both independently and as an overall system.

Further, each of the various elements of the inventive technology and claims may also be achieved in a variety of manners. Additionally, when used or implied, an element is to be understood as encompassing individual as well as plural structures that may or may not be physically connected. This disclosure should be understood to encompass each such variation, be it a variation of an embodiment of any apparatus embodiment, a method or process embodiment, or even merely a variation of any element of these. Particularly, it should be understood that as the disclosure relates to elements of the inventive technology, the words for each element may be expressed by equivalent apparatus terms or method terms—even if only the function or result is the same. Such equivalent, broader, or even more generic terms should be considered to be encompassed in the description of each element or action. Such terms can be substituted where desired to make explicit the implicitly broad coverage to which this inventive technology is entitled. As but one example, it should be understood that all actions may be expressed as a means for taking that action or as an element which causes that action. Similarly, each physical element disclosed should be understood to encompass a disclosure of the action which that physical element facilitates. Regarding this last aspect, as but one example, the disclosure of a "filter" should be understood to encompass disclosure of the act of "filtering"—whether explicitly discussed or not—and, conversely, were there effectively disclosure of the act of "filtering", such a disclosure should be understood to encompass disclosure of a "filter" and even a "means for filtering". Such changes and alternative terms are to be understood to be explicitly included in the description.
Any patents, publications, or other references mentioned in this application for patent are hereby incorporated by reference. Any priority case(s) claimed by this application is hereby appended and hereby incorporated by reference. In addition, as to each term used it should be

understood that unless its utilization in this application is inconsistent with a broadly supporting interpretation, common dictionary definitions should be understood as incorporated for each term and all definitions, alternative terms, and synonyms such as contained in the Random House Webster's Unabridged Dictionary, second edition are hereby incorporated by reference. Finally, all references listed in the following are hereby appended and hereby incorporated by reference, however, as to each of the above, to the extent that such information or statements incorporated by reference might be considered inconsistent with the patenting of this/these inventive technology such statements are expressly not to be considered as made by the applicant(s).

3.5.7. The operation of the TCG Unit

The TCG Unit is controlled by the complex IT data collecting and maintenance system. This system is a automatic process control system supervised by the staff working in the control room/dispatcher center and some control point of the Unit. Both all the TCG Units and the GTE Units are supervised and controled by the central dispatcher system.

3.5.8. References

Some test minutes are attached.

3.6. The GTE (Gas To Electricity) Unit

The manufacturers/suppliers will provide a specific maintenance manual for each major units/parts of the power plant.

Maintenance or overhaul schedule of a gas-turbine:

- Monthly regular maintenance
- Quarterly regular maintenance
- Half-year regular maintenance
- Yearly scheduled maintenance
- 2 000 operating hours preventive maintenance
- 4 000 operating hours preventive maintenance
- 8 000 operating hours preventive maintenance
- Overhaul of the turbine after 30 000 operating hours.

The steam turbine generally requires scheduled maintenance yearly.
Major overhaul of the turbine can be expected after 60 000 operating hours.

3.4.1. Products of GTE Unit

From the above, it has been shown that the electrical-energy-producing unit of the TCG System is the gas turbine and gas motor. The operation of this equipment generates a significant quantity of usable heat, which (depending upon the requirements of the customer/operator) can be harvested as heat energy or further utilized in the generation of electrical energy. This represents an integrated energy system.

Depending upon the customer/operator's requirements, during the operation of the TCG System, over 10MW of heat energy is generated which, under proper conditions, can be utilized in the following ways:

- District heating, heating, cooling
- Additional electricity production

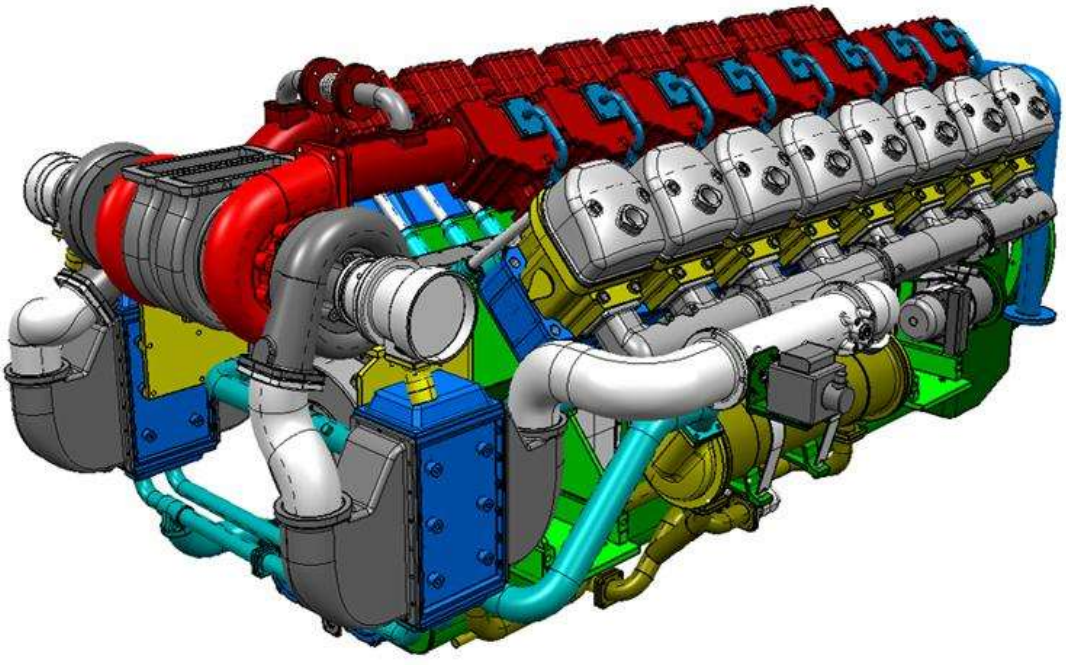

Figure 4.4.1. a-c Gas Motors to GTE Unit

While the pursuit of renewable-based electricity production usually enjoys broader support, government subsidies, etc., unfortunately renewable-based heat generation does not.

Currently, natural gas plays the prominent role in heat energy applications. Extensive, established natural gas networks and the ease and comfort of natural gas-based heating applications coupled with a (thus-far) palatable market price have ensured that natural gas is used for over three-quarters of heat energy needs.

The energy conversion during the process for the overall plant cold efficiency was calculated at a 70% level as a conservative value. However, efficiency calculations from actual operating parameters and test results regularly resulted in higher than 80% cold efficiency for the different feed materials.

In the Table below, the results of the computer model for a TCG unit can be seen. The input/feed material was an average quality municipal solid waste provided by the issuer of the tender. The results in the Table are strictly informational in nature and the actual values of a specific project or for this project may be different based upon the specific physical and chemical parameters of the actual feed material.

Parameters (500 TPD)	**Values**
Quantity of input/feed material (as received basis)	514 ton/day
Calorific value of the feed/input material	12.124 kJ/kg
Quantity of the produced syngas	492.395 Nm^3/day
Quantity from the produced syngas required to sustain continuous production	147.718 Nm^3/day
Quantity of produced syngas available for energy generation	344.676 Nm^3/day
Total energy content of the produced syngas available for energy generation	50,52 MW
Quantity of produced inert ash	77 ton/day

Table 3.4.1.1. Specific parameters of the TCG-UC EL500 TPD TCG Unit

The quality and quantity of the product and by-products can be adjusted taking into consideration the basic parameters of the feed materials mentioned bellow:

1. Energy content,
2. Ash content,
3. Volatile content, and the,
4. Assumption of Carbon in Volatiles,
5. Moisture content

3.4.2. Drawings

3.7. GTL (Gas To Liquide) Unit (Not part of the Project/Plant)

3.7.1. SNG (Synthetic Natural Gas) Unit

3.7.2. Hydrogen Unit

3.8. AUXS (Auxiliary Equipment Units)

3.9. Tests, practical experience and suggestions

3.10. Permitting

3.11. TQM System

3.12. Direct and indirect benefits from the application/introduction the TCG technology

The introduction of the TCG-UC PP into the energy system will significantly contribute to meeting the pledged environmental and energy quotas to be fulfilled, further contribute to and enhance the Bahrain sustainable/green Waste to Energy (W2E) infrastructure, to the environmentally friendly energy production, and help to resolve a number of economic, social and socio-political issues confronting the nation. The different authorities such as the Ministry of Municipalities and Agriculture (MMA), the General Commission for the Protection of Environment and Wildlife (GCPEW) and other government agencies have found the introduction and application of the TCG technology in line with government policy as set for high priority projects and worthy of political and financial support. The introduction of the TCG technology in Bahrain will offer new job creation and open new energy structure from domestic resources.

One of the many exceptional advantages of the TCG system/plant is that it is able to utilize the largest variety of any carbonaceous materials and their mix in any proportion as the feed/input material. Including in the applicable feed materials are the industrial waste and bio-mass, community solid waste, organic (sewage) sludge just to mention a few most problematic, but sustainable, resources.

The other exceptional advantage that the application of a TCG plant offers is the large flexibility in the required end products (through additional down-stream processes), the possibility to extend the original capacity due to the application of modular manufacturing enhanced with almost "self-sufficient" operational possibility on a relatively modest size site, and finally that the system can meet the region's energy needs in a very flexible way.

The TCG technology converts any carbonaceous materials (carbons) into energetic materials in a closed system with Near Zero Emission (NZE) and with extremely high carbon conversion efficiency in an environmentally friendly way. In other words, the TCG technology can produce energy from sustainable (and in many cases harmful) resources. This is the real Waste to Energy (W2E) system.

3.13. The project's goals and objectives

3.13.1. By the introduction of the technology the areas to be addressed and goals accomplished

By the introduction of the technology, many goals/objectives can be accomplished subsequently or concomitantly.

- **Energy production in an environmentally-friendly way**
  - I. Contributing to meet the environmental guidelines set by the European Union.
  - II. Reducing hazardous environmental pollution and contamination
  - III. Reducing the air-pollution

- **Elimination of the community waste for energy generation**
  - I. Significant reduction in size and cost to operate solid waste disposal sites.
  - II. Extension of the useful lifetime of existing community waste disposal sites.

- **Goals and objectives of the project from energetics standpoint**
  - I. Reduction in the nation's energy dependence on foreign sources (it doesn't play role in present tender)
  - II. Utilization of community waste, bio-mass, commercial-, and industrial wastes and other carbonaceous materials as sustainable feed resources for energy generation.
  - III. The application of this technology will significantly increase the ratio of green-energy in the national energy system.

- **Goals and objectives of the project from educational standpoint**
  - I. Environmentally-conscious and green energy promoting education in elementary and high schools can be illustrated by operating plant visits.
  - II. Introduction of middle and high level educational specialist programs, new skill required area technical staff development.
  - III. New applied research and educational (Master and PhD) program development, industry-university cooperative research programs, direct technology transfer in the area of green energy, new catalysis development, process engineering in catalytic conversion fields.

- **Goals and objectives of the project from Employment and civil service (administrative) standpoint**
  I. Local and national energetic materials' economic exploitation and their integration into the green energy production system.
  II. Raw and feed material production and cultivation/growing
  III. Job creation in different areas for increased capacity.
    - Grocery crops cultivation in special growing system to be applied in arid environment.
    - Job creation for energy grass, crops and wood cultivation, and their production.
  IV. Job creation for utilization of waste heat energy in green-houses and related activities
  V. Employment possibilities at different levels for operating the TCG plant and other units.
  VI. Initiation of employment possibilities in small scale producers

- **Goals and objectives of the project of agricultural and animal husbandry standpoint**
  I. Waste heat energy utilization for developing new commercial-scale greenhouses, and cold-storage facilities.
  II. Utilization of manure and bedding straw for energy generation as feed material
  III. Utilization of waste material from agricultural and animal husbandry activities for energy generation as feed/input materials
  IV. Grocery crops growing
  V. Energetic grass, wood and other crops growing
  VI. Utilization of areas with non-producing soils for energetic woods, grass and crops cultivation and related jobs creation.

- **Establishing the basis for environmentally-friendly transportation system**
  I. Mass transportation system with zero or near zero harmful gas emission,
  II. Establishing the basis for hydrogen based energy system.
  III. Support for application of hydrogen-fuel cell technology.
  IV. Developing the nucleus of a hydrogen-fueled transportation system.

- **Goals and objectives of the project from water and ground water protection standpoint.**
  I. Elimination/remediation of infectious water and waste water sites and organic/sewage sludge. Many bacteria became resistant against the antibiotics and remain active and concentrating in the waste water and sewage sludge of waste water treatment plants. The soil's natural remediation ability is not sufficient to eliminate such resistant bacteria, and they can become mobile and end up in the ground water and subsurface reservoirs/resources that may dry up under warm condition and large number of bacteria can become airborne and create a serious environmental and health hazard to the public and the biosphere.
  II. Process waste water that can be neutralized under heat-effect can be utilized as make up water in the TCG plant.

III. Direct protection of ground and artesian water resources.
IV. Reclamation/re-cultivation of waste disposal sites.
V. Reduction of air contamination.
VI. Promotion and introduction of new technologies in Bahrain.
VII. Increasing employment and job possibilities.
VIII. Initiation of energy-related environmental protection programs.
IX. Special supports for the self-governance municipalities.

3.13.2. Advanteges resulting from the successful project execution

- Risk reduction in environmental and bio- spherical hazards. (Health and epidemic risk reduction)
- Elimination or neutralization of contaminants.
- Positive recognition of better environmental guidelines compliance by both the national and international communities.
- Better chance to obtain financial support to specific projects.
- Community waste disposal sites' capacity and life-time can be significantly increased.
- Environmentally safe and inexpensive process to eliminate the hazardous wastes.
- Marginal or un-economical energy resources can be utilized and incorporated into the nation's energy system, both at national and local level.
- Continuous and reliable operation
- Low maintenance and operating costs.
- High value rate of return on investment.

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IV. DESCRIPTION OF THE PROJECT

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4. Project-Specific Data

4.1. Customer

The customer/purchaser and operator of the TCG-UC EL1500TH-TPY type plant is the Project Firm specified below. The majority owner of the plant and/or the Project firm are listed bellow. The parties involved in the project (investor/financier, supplier, and other parties that contribute to the establishment and execution of the project) specify the relationship between the parties and terms of contracts.

4.1.1. Name and address of the Project firm

Name of the company:	**SYNERGY & ITH JV**
Mailing address:	P.O. Box 11400, Manama, Kingdom of Bahrain
Telephone:	NAP
Fax:	NAP
E-mail:	NAP
Skype address and name:	NAP

Table 4.1.1.1. Data of the project firm

4.1.2. Ownership's structure, owners (NAP)

4.1.3. Executive/representative of the Project firm (NAP)

The executive manager of the Project firm will be appointed by the majority owner of the project.
Until the establishment of the Project firm, the investors and the future share holders of the project firm authorized Mr. Marco Richter to represent the Project Firm and the share holders.

Name of the representative:	**Dr. Robert I. Hargitai**
Name of the company	**Synergy Energetics T.R. I. Corp. (EU-Middle East Directorate)**
Mailing address:	H-8002 P.O. Box: 142 Hungary
Telephone:	Phone: +41 71 67 27 319 Cell: +41 76 5610046
Fax:	EU: +36 22 325 235
E-mail:	robert. hargitai@synergytri.eu
Skype address and name:	

Table 4.1.3.1. Data of the executive/representative of the project firm

4.1.4. Contact information of the Applicant

Name of the company:	Synergy Energetics Technological Research Investment Corp.*
Name of owner:	Dr. Robert I. Hargitai
Mailing address:	1309 Enterprize WY, Carson City, Nevada 89703, USA Nevada Business ID: NV20111316666
Telephone:	Phone: +41 71 67 27 319 Cell: +36 303 96 55 51, (+41 76 5610046)
Fax:	-
E-mail:	robert.hargitai@synergytri.eu
Skype address and name:	drhargitai

Table 4.1.4.1. Contact information of the applicant

***CONTRACTOR.**

When small groups of scientists and engineers a few decades ago raised the most important issues and problems related to the continuously increasing quantity of municipal and industrial waste materials around the world and in the oceans, perhaps in general terms they presented the answers as well by calling the at-that-time unresolvable problems and the possible apparatus that may solve them "Stargate".

In human history, we can distinguish various ages such as the Copper, Bronze, or Iron Age. In a similar fashion, our present time could be called the "Plastic Waste Age" due to the immensity of plastic waste gathering around the world and in the oceans.

The awesome quantity of plastic waste, exacerbated by animal and human waste containing pathogens that are immune to many present day pharmaceutical products, present an insurmountable problem in terms of environmental and health hazards that cannot be remedied with environmentally-friendly solutions. The "mega-cities" are suffocating under the solid waste handling and disposal problems that are aggravated further with the quantity and quality of the organic sludge from the waste water treatment plants. The presently applied solutions cost the cities and communities many millions of dollars, aggravating the already dire fiscal and economic situations around the globe.

The Earth is a living inorganic and organic ecosystem that contains a tremendous force to keep the equilibrium or re-establish the equilibrium if any natural or man-made catastrophe or significant intervention disturbs that equilibrium. Nations are ready to accept higher prices of producing and maintaining the energy supplies, agricultural and biological needs of their contemporary societies in order to assure similarly livable conditions for their children and the subsequent generations. Such forward-thinking societies continuously invest huge financial resources to develop new environmentally friendly technologies that create the least hostile interference with the environment.

TCG, Thermo-Chemical Gasification is technology that provides the best environmentally friendly solutions, providing not only technological advantages but economic ones as well, because it utilizes waste material that is a renewable resource and at the same time provides a solution to the both huge waste management, handling and disposal problems for all cities and communities.

CONTRACTOR is committed to further develop, promote and market not only TCG technology and plants, but similarly highly environmentally friendly technologically and the most advanced energy-related technologies, such as producing a user friendly and "free from electric shock" electricity and electricity inverters.

The geological, geographical, meteorological, cultural and local conditions and customs significantly influence the best technology and system that best suits the local, financial and cultural conditions. Therefore, the company developed and endeavors to continually expand its network of representatives and brokers around the world in order to serve most closely the interest of the local communities, and to carry out market surveys and project development activities. Being close to the customer/purchaser assures effective and clear communication between the company and the prospective customer and assists in the timely development of the project. The project has significant positive effects on the local job market, social, educational and humanitarian program developments.

The company has invested a huge amount of human and economic resources to develop a very ambitious financing mechanism and program that would help customers purchasing TCG Plant and systems with less front-end financial burden, i.e. using only 10 – 20% of the total cost as self-financing at the beginning of the project. This financing mechanism constitutes a close cooperation between the customer, supplier, banks and other financing institutions that create a trusting and mutually beneficial relationship that fosters faster project financing and execution. The financier banks or private investors feel comfortable regarding the promised success and reliability of the project and customer.

To develop such a financing mechanism and program required highly reliable, experienced and knowledgeable experts with high professional integrity, and the company is pleased to tie such a team to the company.

The Advisory Board (AB) of the company consists of highly educated, experienced scientists, engineers, financing and marketing professionals with the highest professional integrity. The AB assists the company's executives in determining the viability of the projects, and guides the company on the road to further development and unparalleled success

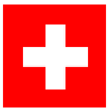
CONTRACTOR is a privately-owned company incorporated in the USA. Beginning with a mainly consulting and managerial profile, the company gradually progressed into complex project development, marketing, project management and (as required) operations. The key personnel of the company exhibit nationally and internationally recognized expertise, and today, CONTRACTOR directly or through its subsidiary companies can deliver engineering, procurement, construction, maintenance (EPCM), and project management services to governments and clients in diverse industries. Clients value CONTRACTOR's reliability, expertise, and safety to execute complex projects around the world.

CONTRACTOR is the recognized partner of many companies/clients who are working in the area of: mineral exploration, mine design and operation, scheduling, designing of subsurface facilities, underground construction and tunneling, rock supporting system , information technology and informatics, urban and industrial waste handling and processing and utilization for energy generation, special (renewable) energy generation problems, solutions and research.

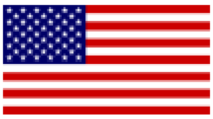
The experts and professionals of our company that are directly employed or are hired through consulting contracts to work with us have significant experiences in a plethora of projects nationally and internationally in such fields as exploration, mining engineering, process engineering and mineral processing, basic and applied research, municipal solid waste handling and processing, energy generation (utilizing both traditional and green energy resources), underground design and construction (tunneling) and underground repositories (radioactive waste repositories), just to name a few. Our company puts the utmost effort into managing project construction as designed, in time and at cost. The business and financial models developed for our projects in close cooperation with purchasers have gained recognition from professionals from the private sector as well as from municipalities and government agencies.

The company prefers to provide to the purchaser the entire system, from the base TCG unit through the downstream unit that ultimately will produce the required product. In such case, the company has maximum control of assuring that the subsequent units that depend upon the performance of the preceding unit will work in full harmony with the highest effectiveness. The entire system will be tested for the set performance before delivery. However, if the customer wishes to purchase only the basic the TCG unit, our company will provide the maximum professional support and assist in selecting the downstream units. In this event, our company's guarantee will not be extended to the units purchased from other suppliers.

PR of China
Alena (Fu Zhou) Industry Investment-Management Co. Ltd.
No.:11-101 Long Feng New Town,
No.19 Huaping Road
Gu Lou District
Fu Zhou City,
P.R.C.



Switzerland
TCG ALENA GmbH.
Unterseestrasse 27,
CH-8280 Kreuzlingen,
Switzerland
Primary Phone: +41 71 672 73 19
Cell phone: +41 76 561 00 46

USA State of Colorado
Unicorp USA International Consulting and Servicing Llc.
17801 Rimrock Dr.
Golden,
CO. 80401 USA

Európai Partner
Clean World TCG Kft.
2800 Tatabánya, Gál István ltp. 403., 7/30

Address: H-8002 Székesfehérvár
P.O. Box.: 142
Primary Phone: +36 22 325 235
Cell phone: +36 30 396 55 51

Some reference projects of our company and experts

TCG References,

- OHIO 300TPD,
  This plant was established about eight years ago, near the Energy Center of Ohio University in Toledo/Ohio. It had been working for about two years in Colorado at the manufacturer's site and then it was sold to a private company in Toledo/OH.

- 200 MW electricity capacvity power plant, for coal as feedstock and established by Philips company,

- Texas / USA,
  Under development

- Oklahoma / USA
  Under development

- New Mexico / USA several projects in different stages
  Under development

Other references

- Yucca Mountain Project, USA

The CONTRACTOR Energetics T.R.I. Corp. and its CEO personally has been working for several years with the Colorado School of Mines (CSM) as expert in underground facility constructing and supervising, authorized and orderd by the Department of Energy of United States of America.

The **Yucca Mountain Nuclear Waste Repository**, as designated by the Nuclear Waste Policy Act amendments of 1987, is to be a deep geological repository storage facility for spent nuclear fuel and other high level radioactive waste. It is located on federal land adjacent to the Nevada Test Site in Nye County, Nevada, about 80 mi (130 km) northwest of the Las Vegas Valley. The proposed repository is within Yucca Mountain, a ridge line in the south-central part of Nevada near its border with California. The location has been highly contested by environmentalists and non-local residents in Las Vegas, which is over 100 miles (160 km) away. It was approved in 2002 by the United States Congress.

Federal funding for the site ended in 2011 under the Obama Administration via amendment to the Department of Defense and Full-Year Continuing Appropriations Act, passed on April 14, 2011.[2] The Government Accountability Office stated that the closure was for political, not technical or safety reasons.[2] This leaves US non-governmental entities, such as utilities without any designated long term storage site for the high level radioactive waste stored on-site at various nuclear facilities around the country. The US government disposes of its waste at WIPP in New Mexico, in rooms 2,150 feet (660 m) underground. The Department of Energy (DOE) is reviewing other options for a high-level waste repository and a Blue Ribbon Commission established by the Secretary of Energy released its final report in January 2012. It expressed urgency to find a consolidated, geological repository, and that any future facility should be developed by a new independent organization with direct access to the Nuclear Waste Fund, that is not subject to political and financial control like the DOE.

- <u>Hungarian National Radioactive Waste Manegement Program</u>

The CONTRACTOR through its CEO and President has been authorized to represent the CSM in the Hungarian National Radioactive Waste Manegement Program, providing theoretical and experimental support and supervision in those very important, high ranked issues that are controlled by the International Atomic Energy Agency (IAEA).

- <u>DeBeers, South Africa</u>

The CONTRACTOR was working for the „De Beers" several times in estimating underground bodies, and in designing the exploitation and exploration system of different sites.

The De Beers Group of Companies has a leading role in the diamond exploration, diamond mining, diamond retail, diamond trading and industrial diamond manufacturing sectors. The company is currently active in every category of diamond mining: open-pit, underground, large-scale alluvial, coastal and deep sea.[2] The company operates in 28 countries and mining takes place in Botswana, Namibia, South Africa and Canada.

The company was founded in 1888 by British businessman Cecil Rhodes, who was financed by the South African diamond magnate Alfred Beit and the London-based N M Rothschild & Sons bank. In 1926, Ernest Oppenheimer, a German immigrant to Britain who had earlier founded mining giant Anglo American plc with American financier J.P. Morgan, was elected to the board of De Beers. He built and consolidated the company's global monopoly over the diamond industry until his death in 1957. During this time, he was involved in a number of controversies, including price fixing, antitrust behaviour and an allegation of not releasing industrial diamonds for the US war effort during World War II.

- <u>Ecole Nationales Superieure des Mines de Paris (ENSMP)</u>

The CEO of CONTRACTOR was working for the

MINES ParisTech (officially **École Nationale Supérieure des Mines de Paris (MINES ParisTech)**, also known as **École des Mines de Paris**, **ENSMP**, **Mines Paris** or simply **les Mines**), created in 1783 by King Louis XVI, is one of the most prominent French engineering schools (see Grandes écoles) and a member of ParisTech (Paris Institute of Technology) and PSL* (Paris Sciences et Lettres).
Mines ParisTech is reputed for the outstanding performance of its research centers and the quality of its international partnerships with other prestigious universities, which include Massachusetts Institute of Technology (MIT), California Institute of Technology (Caltech), Shanghai Jiao Tong University, University of Hong Kong, National University of Singapore (NUS), Novosibirsk State University, Pontifical Catholic University of Chile and Tokyo Tech.

4.1.5. Contact information of the executive manager/representative

Name of owner:	Dr. Robert I. Hargitai
Mailing address:	CONTRACTOR Energetics T.R.I. Corp. EU representation H-8002 Szekesfehervar, P.O. Box : 142 Hungary
Telephone:	+36 303 96 55 51
Fax:	+36 22 325 235
E-mail:	robert.hargitai@CONTRACTORtri.eu
Skype address and name:	drhargitai

Table 4.1.5.1. Contact information of the representative

4.1.6. The structure of the ownership, owners (NAP)

Name/Type **(private individual, self-governance municipality, company)**	**Level of ownership**

Table 4.1.6.1. The ownership system of the project company

The share holders of the project Company will be determined in a later stage.

The feed/input material (MSW) is secured and guaranteed by the Government of Bahrain. The terms of delivering the feed/input materials for the landfill site are specified and agreed upon in the eather in theTender documentation contract drawn between the Project Firm and the Government of the Kingdom of Bahrain.

The Tender Document determines the exact financing and performance procedure of the entire project.

4.1.7. Customer/purchaser (s) Ownership Arrangement

As mentioned in Section 3.1.6 in this development/preparatory stage of the project the exact and specific information concerning the Project Company, as well as the precise distribution of ownership is not decided firmly and it may be changed.

To comply with this requirement the following information are provided for information basis only:

4.1.7.1. company 1

NAB

4.1.7.2. company 2

NAB

4.1.7.3. company 3

NAB

4.1.7.4. company 4

NAB

4.1.8. Supplier of the TCG plant or power system

The patent-protected utilization of the TCG technology is wholly controlled through the assigned company.
The purchaser of a TCG plant/unit will receive a non-transferable operation license from the supplier without any additional licensing fee for the lifetime of the TCG plant/unit.

The Supplier of the TCG-UC PP will provide the appropriate guarantees and liability insurance for the purchased system, either directly or through the manufacturer (s).

The Supplier of the TCG system either directly or through a third party is ready to operate the purchased system or provide long-term maintenance under a separate contract should the project owner request it.

The Supplier encourages close cooperation with the purchasers from the inception of the project through the design and manufacturing processes, and is prepared to provide documentation concerning the authorization (s) of its activities.

Some subcontractors and suppliers of TCG Projects and their activity are as follows:

- Wärtsilä Corporation
  Gas turbines, and /or electricity generator units

Wärtsilä /ˈværtsilæ/ is a Finnish corporation which manufactures and services power sources and other equipment in the marine and energy markets. The core products of Wärtsilä include large combustion engines used in cruise ships and ferries. As of 2013 the company employed 18,663 workers in more than 70 countries and it is headquartered in Helsinki.
Wärtsilä has three main businesses; Power Plants focussing on the energy market, Ship Power focussing on the marine market and Services which is supporting both markets. Wärtsilä operates globally but its Ship Power division is heavily focused on Asia.

- General Electric

General Electric (**GE**) is an American multinational conglomerate corporation incorporated in New York and headquartered in Fairfield, Connecticut.[1][3] As of 2015, the company operates through the following segments: Power and Water, Oil and Gas, Energy Management, Aviation, Healthcare, Transportation, and Capital.

In 2011, GE ranked among the Fortune 500 as the 26th-largest firm in the U.S. by gross revenue,[4] as well as the 14th most profitable.[5] However, the company is listed the fourth-largest in the world among the Forbes Global 2000, further metrics being taken into account.[6] Other rankings for 2011/2012 include No. 7 company for leaders (*Fortune*), No. 5 best global brand (*Interbrand*), No. 63 green company (*Newsweek*), No. 15 most admired company (*Fortune*), and No. 19 most innovative company (*Fast Company*).[7]

- Solar Turbines

Solar Turbines Incorporated, a wholly owned subsidiary of Caterpillar Inc., designs and manufactures industrial gas turbines for on- and off-shore electrical power generation, for marine propulsion and for producing, processing and transporting natural gas and oil. Solar Turbines is one of the world's leading producers of industrial gas turbines up to 30,000 horsepower (22,000 kW). There are more than 13,900 Solar Turbines gas turbine systems installed in 98 countries worldwide that have collectively logged more than 1.7 billion hours of use.
Founded in San Diego, California, United States in 1927 as **Prudden-San Diego Airplane Company**, the company initially designed, manufactured and sold airplanes.
After the departure of its founder, George H. Prudden, the company changed its name to **Solar Aircraft Company** in 1929.
The Great Depression of 1929 forced Solar Aircraft Company to re-focus its efforts into manufacturing aircraft components for other manufacturers. The company grew considerably during World War II and was forced to diversify into non-aircraft products due to the steep drop in business after the war.
Solar Aircraft Company's expertise in hard-to-manufacture parts able to withstand high-temperatures led to contracts to produce jet engine components. Solar Aircraft began to design and manufacture completed turbine engines for the United States military for applications such as auxiliary power units.[7] Solar Aircraft continued to expand its product line and grow its business until it was purchased by International Harvester Company in early 1960, becoming the **Solar Division of International Harvester** in 1963.
In 1973 the Solar Division of International Harvester exited the aerospace industry to focus solely on industrial turbines. In 1975 the development and manufacture of the Solar Division's radial engines was moved into a newly formed Radial Engines Group, renamed the Turbomach Division in 1980.

Solar Turbines Incorporated became a wholly owned subsidiary of Caterpillar Tractor Co. after Caterpillar purchased the assets of the Solar Division and the Turbomach division from International Harvester on May 31, 1981.[2] In 1985, Caterpillar sold the Turbomach Division to Sundstrand Corporation.

- Siemens Energy Sector
  The **Siemens Energy Sector**, founded on January 1, 2008, is one of the four sectors of Siemens AG corporation. The company generates and delivers power from numerous sources including the extraction, conversion and transport of oil and natural gas in addition to renewable and alternative energy sources.

- Advanced Mechanical Solutions, LLC

- AI International

- Alpha-Omega Environmental
  Water ionizator, and waste water handling
  Alpha Omega Environmental Laboratory Inc., an environmental testing laboratory, provides a range of environmental testing and related services to consulting engineers/professional clients; business and industry; federal, state, and local governments; public and private institutions; and individuals. The company was formerly known as Stantec Consulting Services. Alpha Omega Environmental Laboratory Inc. is based in Columbus, Ohio. As of April 30, 2010, Alpha Omega Environmental Laboratory Inc. operates as a subsidiary of Pace Analytical Services, Inc.

- Can-Am Group

- CC Fab

- Centennial Equipment

- **Cold Shot Chillers**
  Cooling system,
  Cold Shot Chillers® manufactures economical, ruggedly dependable industrial air cooled chillers, water cooled chillers, portable chillers and central chillers. Our industrial water cooled chillers and air cooled chillers serve a variety of different industries and applications. Contact Cold Shot Chillers® today for all your industrial chiller needs!

- **Con-V-Air**
  Air locks, fedding system, air locks, material and feedstock handling
  CON-V-AIR's design & engineering team implement the latest technological advances in bulk handling equipment to suit the customer's needs for:
  - Pneumatic conveying
  - Screw conveyor
  - Silos
  - Powder Handling
  - Bulk Bag unloading stations

- **Dry Fabrication and Welding Inc.**
  Frame work system, docking units, reflectors and pyrolysis chamber,
  Dry Fabrication is here to help you face today's challenges! They want to be part of the dedicated team that designs, manufactures, constructs and helps maintain your business.

  Whether it is Process Chemical, Manufacturing, Coal Processing, Fabrication or Oil Field Services, DRY has the team of experienced veterans with loyalty, longevity and proven know-how to address your needs.

  They provide their customers with on-time service, proven performance and consistent top quality workmanship. Dry Fabrication, INC. is a diverse Company. They pride themselves on being able to handle a wide variety of fabrication and installation projects.

- **Federal Screen Products**
  Quenching, and waste water treatment containers,

- **G W Welding**
  Welding controling, stainless steel fittings, joints, and tubes welding and controling,

- **Ingersoll Rand**
  Air Compressors, pumps,

- **Intermountain Valve and Control**
  Flow controling, valves, water and gas flows controling,

- **Maxon Corporation**
  Gas tubes and valves, burners, and gas system controling

- **O2-N2**
  Gas (Oxygen, Nitrogen,) elements measuring system development and consulting

- **Orbit Industries, LLC**
  Metal Fabrication and Machining, pressureized wessels

- **Roto-Disc Company**
  Valves , flow control, air-locks and special form valves and air locks into extrem high temperature environment

- **Rust Automation and Controls Inc.**
  System design for air, water, gas, heat, etc, flow controling systems

- **Siemens Water Technologies Corp.**

- **Venturedyne Ltd,**

Waste water treatmen plan and pressure filter system for micro sized grains, 1er, 2nder and tercier cyclone systems for gas cleaning, injector for mixing system of clean and waste waters

- **Wilson-Mohr**
  Total process control and automation, system integration,

4.2. Governmental supporting documents, declarations

The Tender document contains all the official sapport provided by the Government, through the Ministry or other governmental offices or organizations.

4.3. The Site

The required size of the project's site and the relative location of the units depend upon numerous parameters including but not limited to the capacity of the plant, geography of the available site, the location and availability of utilities, the location of the "connecting points" of the products to the market, the quality and quantity of the feed/input material(s) and availability and location of the waste material disposing systems, among many others.

Consequently, it is of the utmost importance that the detailed and complete site-specific data (including city or community requirements and ordinances) in order to develop a conceptual plan that offers the optimal design in terms of function and operations costs under the site-specific advantages and constraints are provided by the Government or its representative department.

The site, - determined in the Tender documentation – consists of two parts. As it can be seen in the Figure 3.3.1., the Northern part is 230 000 sq.m., and the Southern one is 330 000 sq.m.

The areas are provided by the Government and can be used for the entire period of the project.

Fig. 4.3.1. Aerial view of the parts of the landfill site

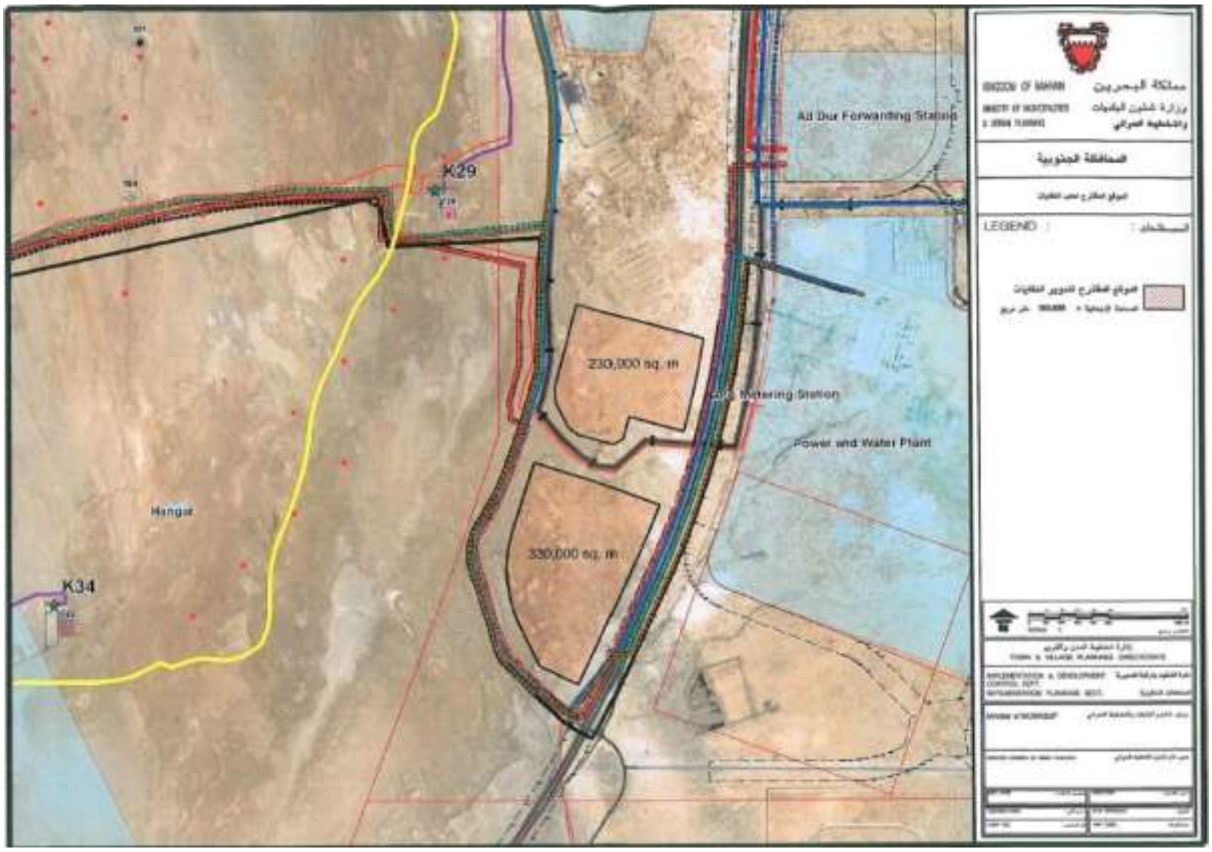


Fig. 4.3.2. The two parts of the site specified in the Tender documentation

Fig. 4.3.3. The site of the TCG-UC EL1500TH-TPY project

Due to the flexibility of the TCG-UC system, the feed/input material handling and processing system (called the AUXS/Pre-Selection Plant) and the different units of the power plant (TCG, GTE, etc.) can be located away from each other without any major disadvantages or significant cost effects, according to the local conditions. In the case that the waste material site fulfills a centralizing function (smaller sites transport the material to this site) and it is large enough to accommodate the feed/input material processing and handling system that may consists the pre-sorting, shredding and safety storage facility, the AUXS system should be located in that site away from the TCG and other units.

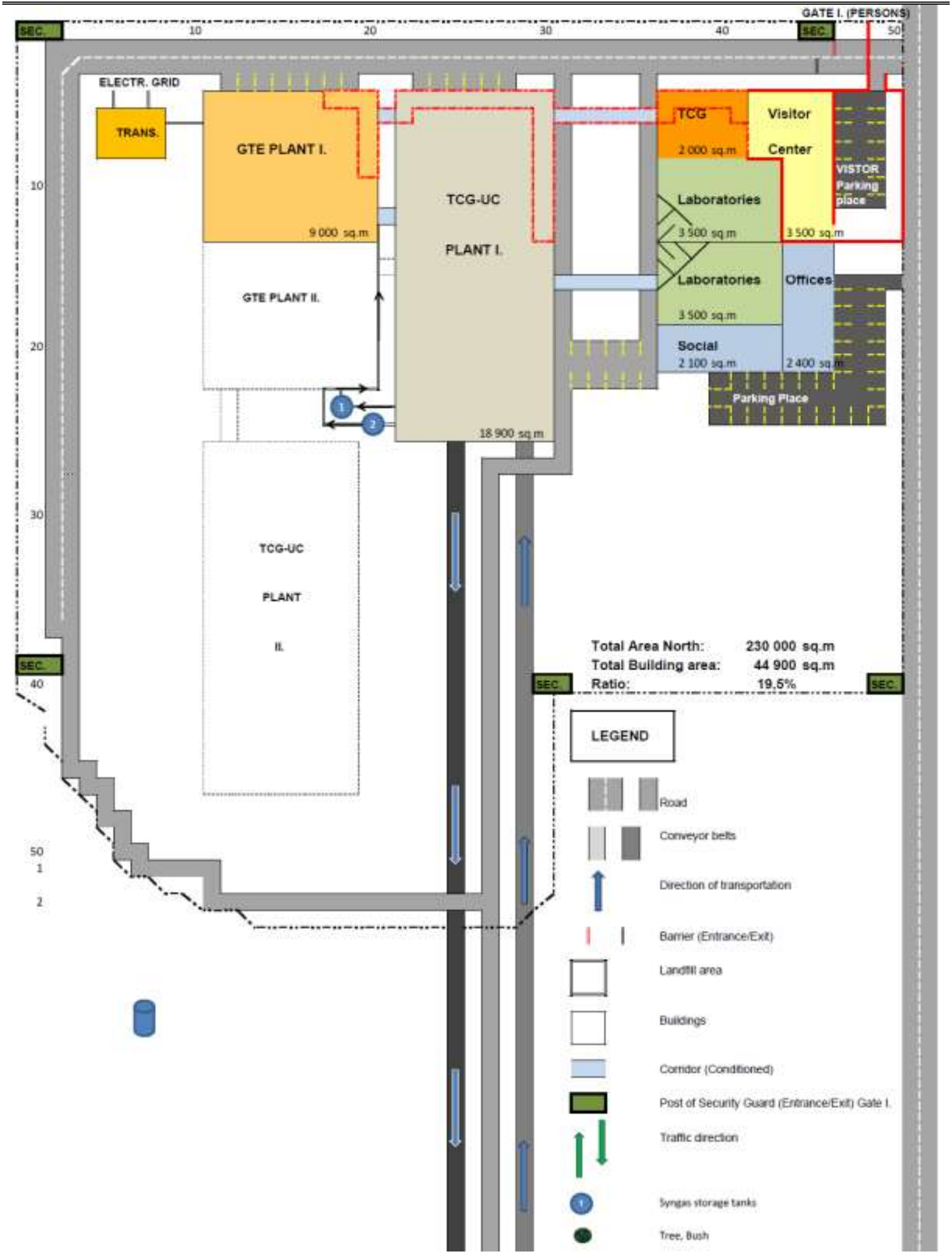
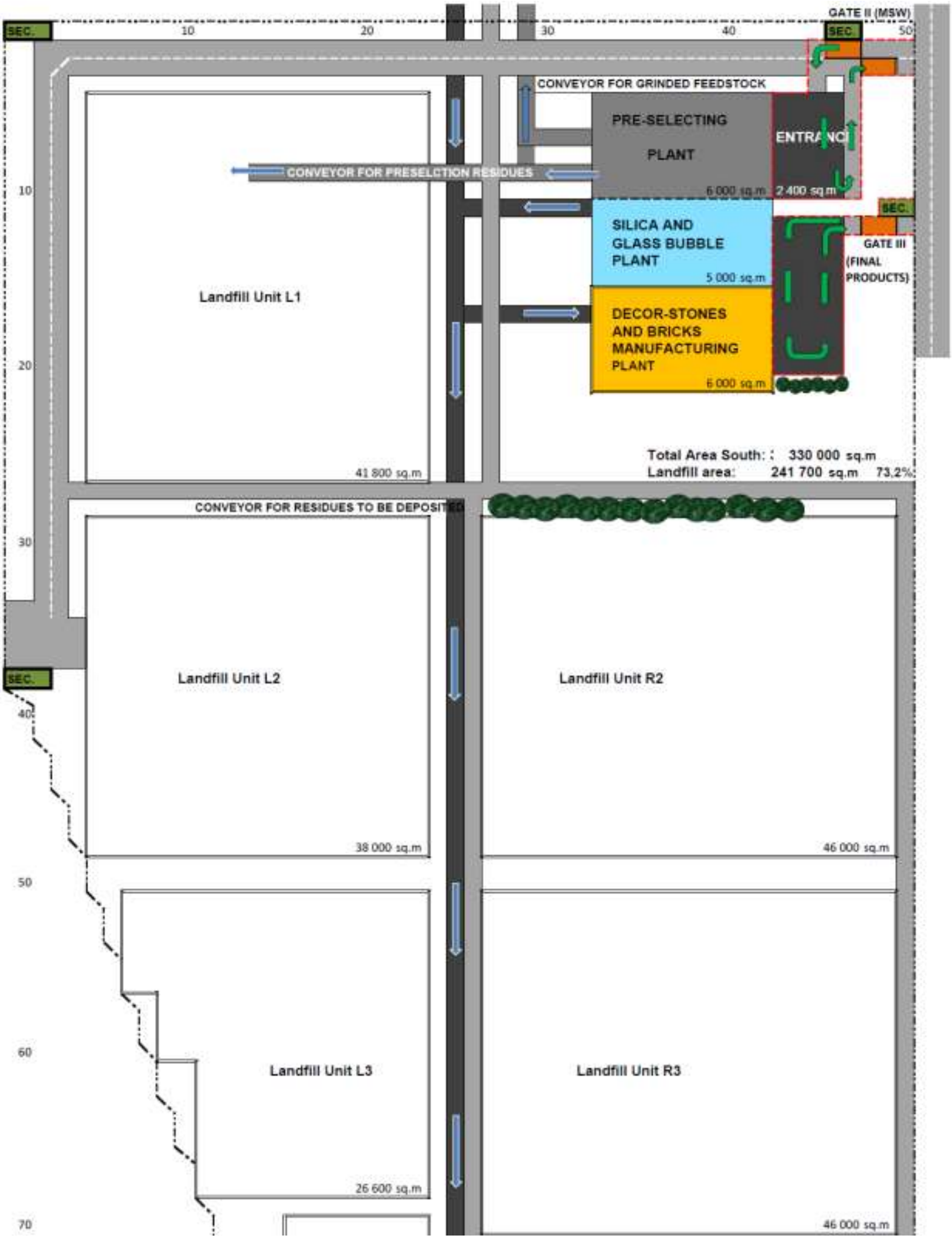


Figure 4.3.4. The proposed system in the Northern site



GATE II (MSW)
SEC.
10
20
30
40
50
CONVEYOR FOR GRINDED FEEDSTOCK
PRE-SELECTING PLANT
6 000 sq.m
ENTRANCE
2 400 sq.m
CONVEYOR FOR PRESELCTION RESIDUES
SILICA AND GLASS BUBBLE PLANT
5 000 sq.m
GATE III (FINAL PRODUCTS)
DECOR-STONES AND BRICKS MANUFACTURING PLANT
6 000 sq.m
Landfill Unit L1
41 800 sq.m
Total Area South: : 330 000 sq.m
Landfill area: 241 700 sq.m 73,2%
CONVEYOR FOR RESIDUES TO BE DEPOSITED
Landfill Unit L2
38 000 sq.m
Landfill Unit R2
46 000 sq.m
60
70
Landfill Unit L3
26 600 sq.m
Landfill Unit R3
46 000 sq.m

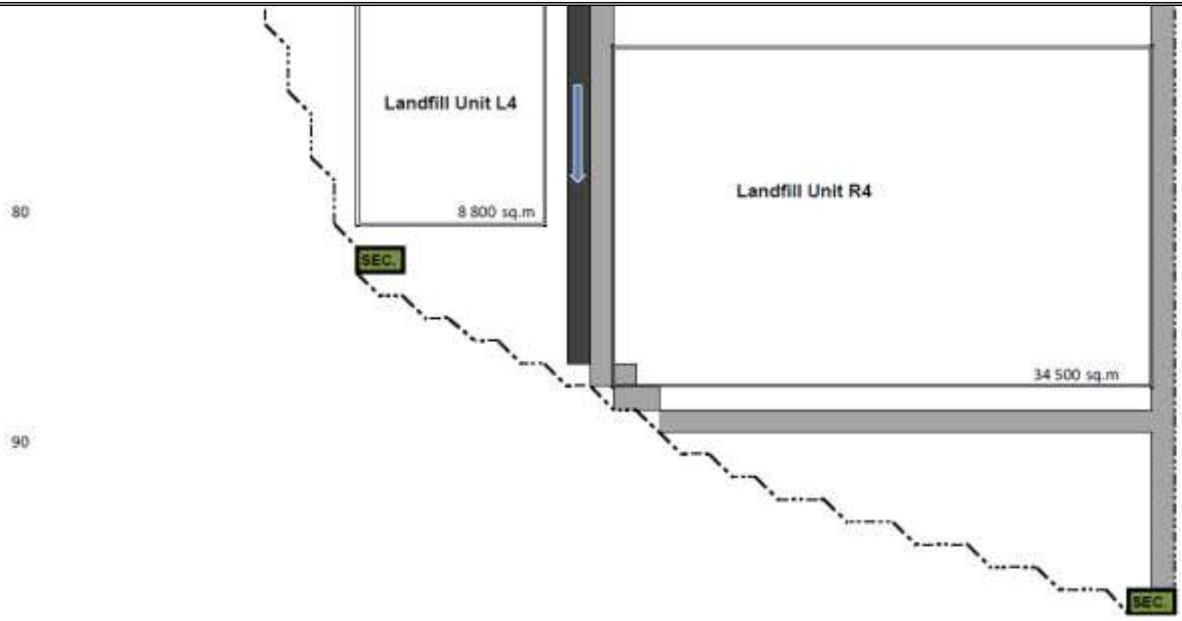


Figure 4.3.5. The proposed system in the Southern site

As previously mentioned, two basic alternative solutions can be considered for the power plant arrangement, and evaluated largely by the local conditions and availability of the required size of site. The location and size of the power plant's site has unlimited variety depending upon the local conditions, geography, availability of possible sites, special city or community considerations, and esthetical and architectural expectations, therefore in this text, the site's size requirements are given based on the effective and safe operation of the basic units without taking into account local constraints or advantages.

The total area of the landfill site is 230.000 m^2 + 330.000 m^2 altogether 560.000 m^2. However, area requirement may change depending upon the final design and planned arrangement of the units on the site, this area is enough to fulfill all the requirements declared by the Governement of Bahrain in the Tender documentation.

The breakdowns of the total area requirement between the major plants/units are:

No.	Facility/Unit	Total area (m^2)
	The waste/feed material storage area	
1.	Total area available	241.700
	The Units of the Pre-selection Plant	
2.	Waste system entrance area	2.400
3.	Waste sorting and shredding facilities/equipment	6.000
	The Units of the Gasification- and Power Plants	
4A.	TCG Plant I	18.900
5A.	GTE Unit I. (Electricity production: gas motor/turbine, generator)	9.000
	Reserved areas	

4B.	TCG Plant I	18.900
5B.	GTE Unit I. (Electricity production: gas motor/turbine, generator)	9.000
6.	Visitor center	5.500
7.	Laboratories	7.000
8.	Office building(s)	4.500
9	Silica and Glass Bubble Unit	5.000
10	Decor-Stones and Bricks Unit	6.000

Table 4.3.1. The area of the Plants and

Considering the daily quantity of the MSW the above listed plants and units are suitable and enough to process the currently available quantity of MSW.

Figure 4.3.6. The location of the landfill site

4.3.1. Layout/plot specification

Considering the total and daily quantity of the MSW and the the feedstock carbonaceous part of the waste, the TCG Unit has to consist of seven TCG-UC 500TPD Units. As it can be seen in the process flow chart the quantity of the carbonaceous material is cca.3000TPD, and it is continuously increasing from year to year with a 5% ratio, as it was written in the tender document. Securing the safe and stabile service 6, 500TPD capacity TCG unit will be operated in a continuous way and the seventh one is the "Hot Spare", that can be swithed on ina very short time if any of the 6 has any problem or is maintained or under construction.

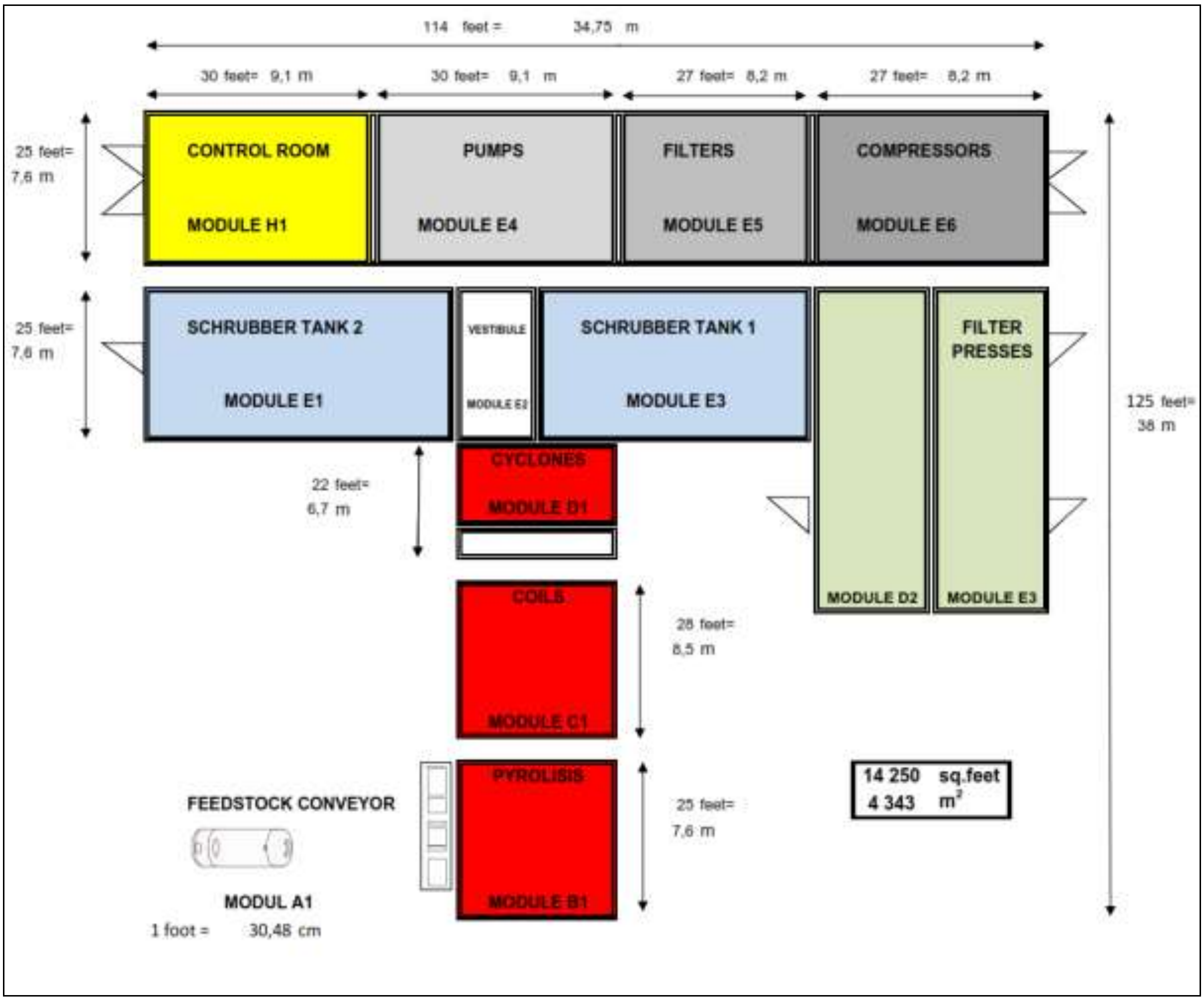


Figure 4.3.1.1 The Layout of a TCG 500TPD Unit

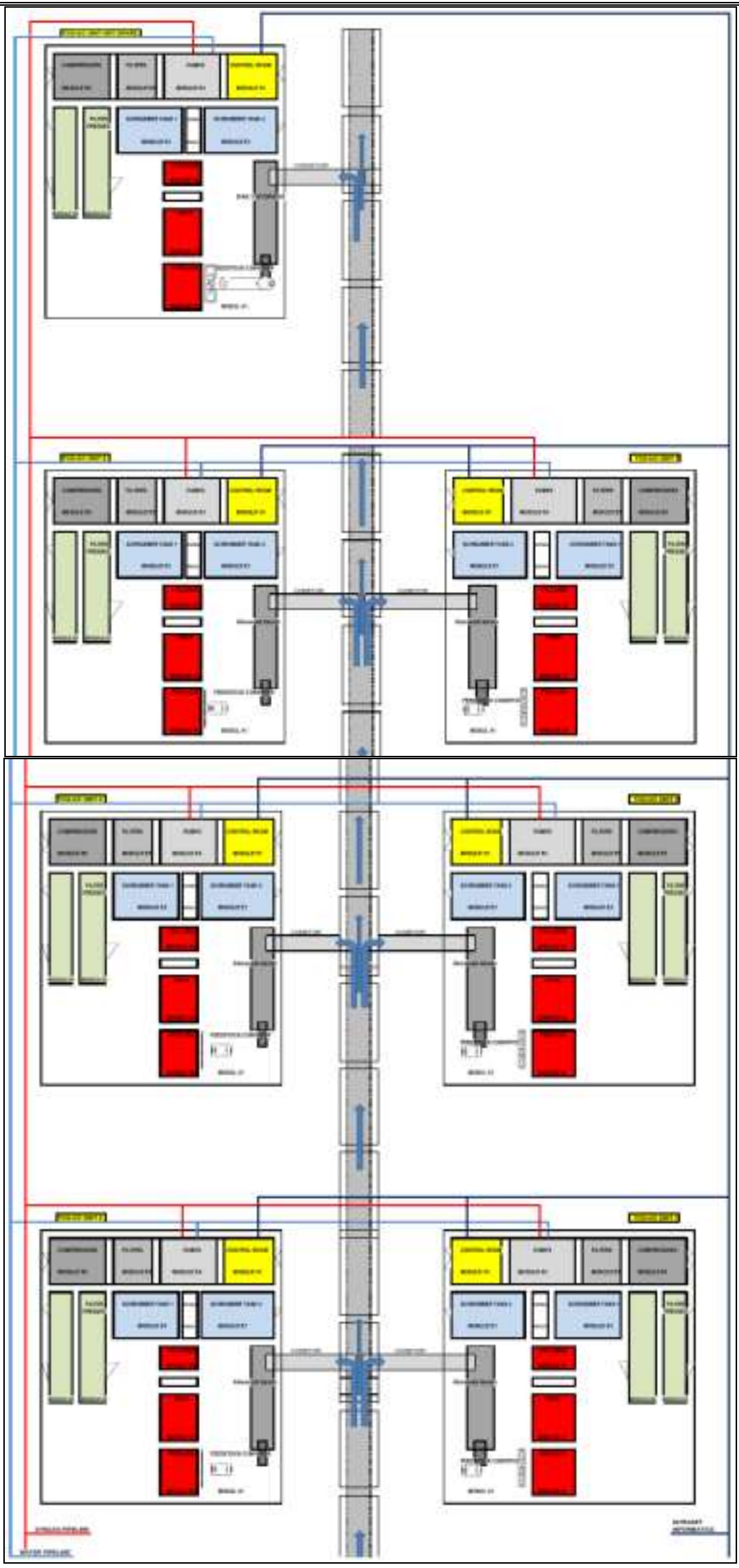


Figure 4.3.1.2 The Layout of a TCG Unit of the plant

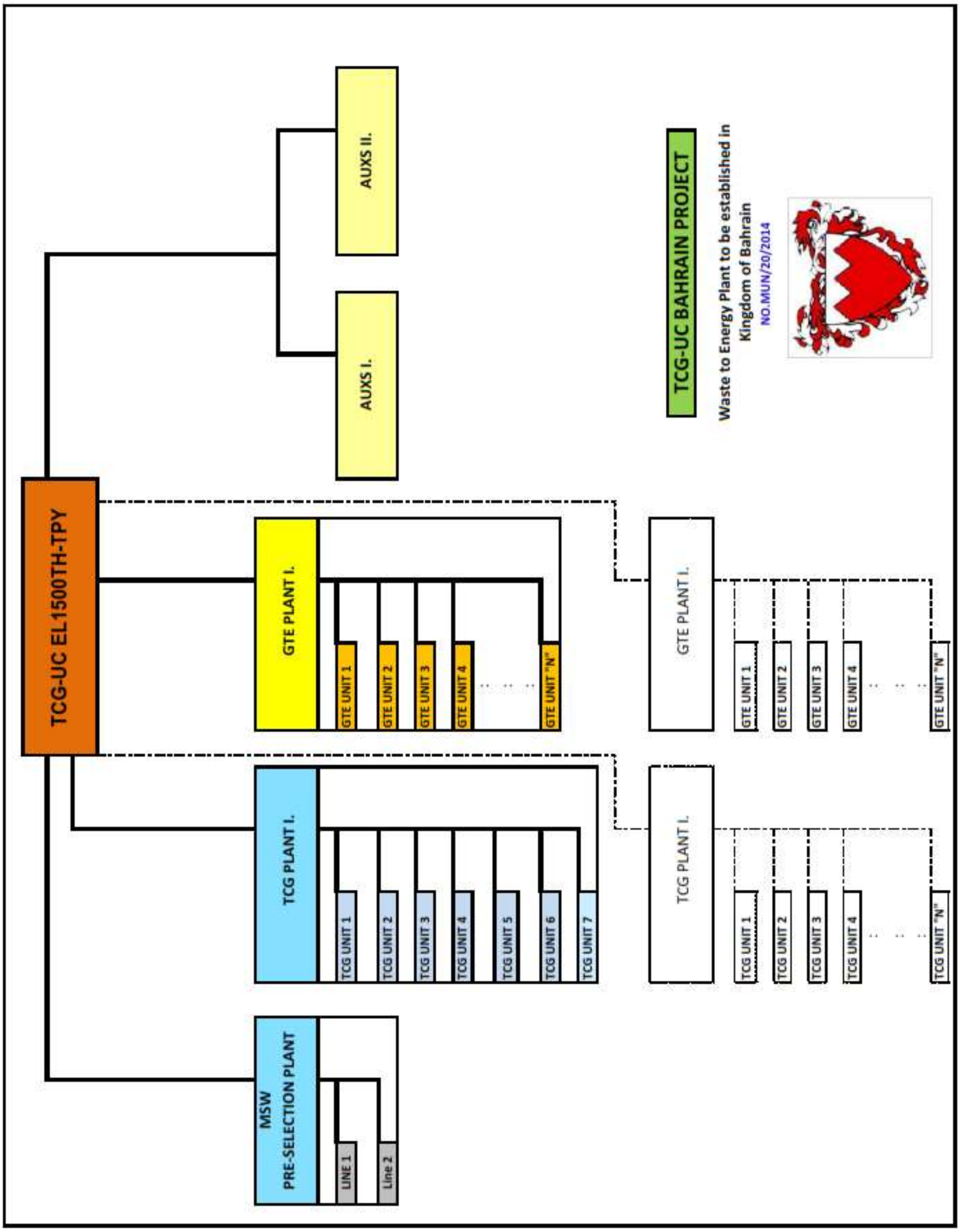


Figure 4.3.1.3 The system drawing of the TCG-UC EL1500TH-TPY Plant

4.3.2. Copy of the ownership/title

(NAP)

4.3.3. Location/site of the waste pre-sorting and processing unit (AUXS)

The required power will be made available from the electrical sub-station located on the Northern part of the landfill site. The pre-sorting facility is designed to the North-Eastern edge of the Southern site, considering the wind and the technical environments and circumstances.

The MSW pre-selection facility and its entrance is separated from other entrances of the sites. The refuse lorry wagons are registered at the gate by the security guard and weighted to register the total "entry weight" of the truck.

After emptying the waste to the appropriate inlet/gate, the refuse lorry wagon leaves the site at the exit gate, where the "exit weight" is registered by the computer system. Using these two weights the total transported MSW can be calculated.

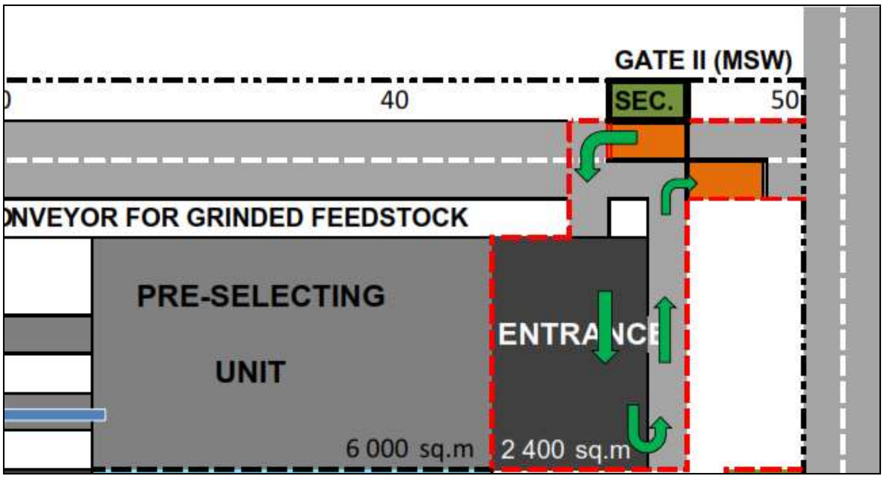


Figure 4.3.3.1. The Pre-Selecting Unit (AUXS)

The wastes are pre-selected into several categories as requested in the tender document. The Figure 4.3.3.2. decribes the selecting system.

Due to the related size requirement the first auxiliary equipment of the plant, - when the waste material enters into the Pre-selecting Plant, - is the grinding machine unit, consisting of special grindingchopper units for mixed organic and inorganic waste materials.

The waste materials must be grind/chopped into 1-1,5 inch size, before it is fed into the TCG/gasification units.

Some important specific information about the Grinding Machines/Choppers:

- NOT a vertical impact mill
- Infinitely adjustable
- Kinetic Impact Energy
- No Close-Action Surfaces
- No Explosions in 20 years
- Moisture Reduction
- Rotary Inertia / Gyroscopic Action
- Vortex Circulation
- Low cost per Ton

Some samples of the feedstocks to be grinded

- e-waste to powder for extraction of precious metals
- concrete and asphalt for recycling
- alfalfa and other grains for mixing and feeding animals
- factory seconds for recycling
- wood waste to mulch and for general reduction
- green waste
- drywall to lime powder
- Garbage
- Rock
- C and D
- Cardboard
- Dirt
- cinderblock
- pallets
- auto shredder f luff
- sand casting molds
- phosphate rock
- sulfur blocks
- manure
- chicken litter
- wastewater sludge cake
- glass
- aluminum
- plastics
- lime
- dead animals
- Lignite (brown coal)
- Etc!

Some references from purchasers

"WE COULDN' T BELIEVE HOW THE MACHINE WOULD GRIND CONCRETE INTO SAND WITH NO SWEAT"
Dennis Dean, RSI, Oregon.

"WE HAVE PROCESSED CATTLE MANURE, CHICKEN LITTER, ALFALFA, ROCK, GRAVEL, AND GREEN WASTES WITH THE POWERMASTER, WITH NO PROBLEMS."
Dennis Williams, Diamond Four, Atwood, Colorado.

"THE POWERMASTER PROCESSED OUR MIXED WOOD WASTES INTO A FINE SOIL IN LARGE QUANTITIES WITHOUT ADDITIONAL SCREENING."
Ollie Tyson, Houston Texas.

"THE RECYCLONE IS THE MOST FORGIVING DEVISE WE HAVE EVER SEEN."
Ralph Goble, Sr. Denver, Colorado.

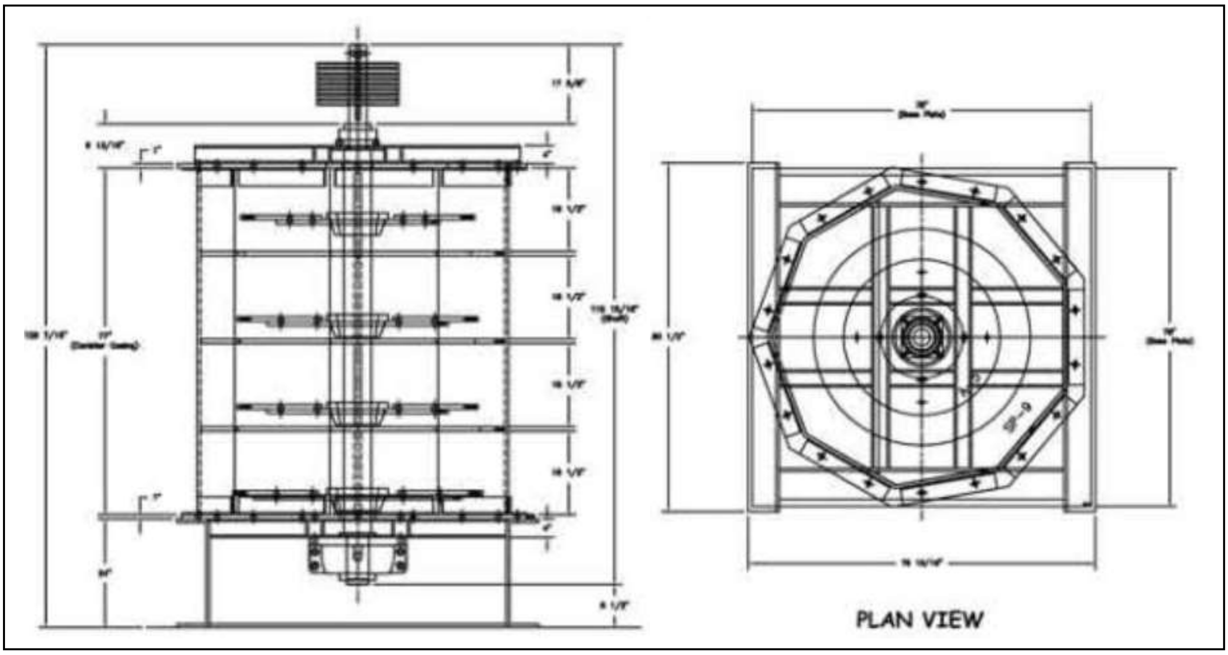


Figure 4.3.3.2. The grinding unit

The Difference between the PowerMaster and Other Reduction Methods

The mechanical action of this processor is unlike any other mill. The PowerMaster is not a vertical hammer mill. There are several physical methods at work in this unit that are not employed in hammer mills or in any type of slow speed shredders.

1. Kinetic Impact Energy

Instead of a physical crushing, requiring a hammer and anvil type action, or shredding, which requires a shearing action, the main action of the PowerMaster is the acceleration of materials to a high velocity and then the impact of those materials against an immovable surface.

2. No Close-Action Surfaces

There are no close hammer-to-anvil surfaces inside a PowerMaster. In many applications, 4 inches is the closest distance between a rotating and a fixed surface. This prevents wear, excessive maintenance and downtime.

3. Kinetic Impact Moisture Reduction

The high speed circulation of materials inside the PowerMaster results in millions of impacts a second that increases exposure of moisture bearing surfaces and Btu transfer to reduce moisture an average of 50% for feedstocks with original moisture contents less than 60%. High range moisture content materials usually require multiple passes.

4. Rotary Inertia / Gyroscopic Action

Due to the balance and construction of the PowerMaster, the rotary motion of the processor produces a balanced high torque flywheel action that easily defeats a high rate of loading.

5. Vortex Circulation

The high-speed impellers create a vortex air stream inside the machine that acts to propel materials against the sidewalls of the unit. This same vortex circulation acts to transfer released moisture into the discharge air stream.

PM	**Physical Specifications**
Height	13'6"
Weight	18,000 - 24,000 lbs
Horse Power	125 HP to 500 HP
Adjustability	Fully adjustable infinitely for particle size
Air flow	8,000 cfm to 50,000 cfm (adjustable)
Foot print	8' X 8'
Operational speed	840 rpm - 940 rpm (adjustable)
Capacity	6 tons per hour - 200 tons per hour
Drive	Electric motor via Power Bands or multiple V belts
Manufacturing materials	Proprietary

Warranty	1 Year up to 3 Years

PM
1100 NW Loop 410, Suite 700
San Antonio, TX 78213
210-881-0995
866-469-7289

Operational Benefits The PowerMaster ReCyclone is a low maintenance piece of equipment that continually performs its job effortlessly. No other processor in the world can accept tramp metal like a PowerMaster.

1. Low Cost-Per-Ton Operation

All aspects of the heavily built ReCyclone are designed to provide the operator with a long-lived unit with low cost-per-ton processing.

2. Low Energy Costs

The ReCyclone makes efficient use of energy by employing an engineered drive system that combines cost effective electric drive with the power savings of a large balanced flywheel. The ReCyclone requires 10 horsepower to process one ton of MSW. This 10:1 ratio is the most efficient horsepower-to-processed-ton ratio in the industry.

3. Easily Handles Tramp Metals

The PowerMaster Recyclone™ was built to handle tramp metal. A case hardened piece of tramp metal will severely damage or destroy most mills and result in thousands of dollars of damages and days or weeks of lost production time. The PowerMaster Recyclone™ can sense the presence of an unprocessable item in a single second and automatically shut down. The cost of even a severe tramp metal incident, such as might occur with the introduction of a 150 lb case hardened anvil, in a PowerMaster is typically less than $50 for replacement impellers and shear bolts. Two men with an air wrench can bring a Recyclone series processor back on line in less than 30 minutes after the majority of severe tramp metal incidents.

4. Durability

PowerMaster Recyclone's inexpensive bolt-in vortex impellers can outlast any hammer mill, flail mill, or impact crusher hammer in the business simply because, unlike most reduction equipment, there is no close hammer to anvil grinding action that constantly deteriorates wear surfaces. In other mills, replacement cost of attrition surface parts and loss of production due to repair and maintenance are usually the single most significant factor in determining per ton costs. The ReCyclones low maintenance and overhaul costs translate directly into low cost-per-ton production.

5. Low Maintenance

The PowerMaster typically requires less than 30 minutes of preventative maintenance a day. An overhaul requires less than 64 man-hours. Total parts rarely total $5,000. a year. No other mill on the market has lower maintenance costs.

6. Size Reduction
The ReCyclone can be adjusted internally to provide a wide range of sizes. Depending upon feedstock, the PowerMaster can process feedstock material over a wide range of material sizes, typically from 8" down to 20 microns.

7. Infinite Adjustability
ReCyclone's are built as a processor platform that can quickly and easily be reconfigured to perform a wide range of applications. The easily adjustable internal impellers are sized, multiplied, and adjusted vertically to provide an infinite range of sized output. The number of rotors may be varied in the machine to provide additional sizing or drying characteristics. A factory representative will "tune" your PowerMaster to your requirements.

8. Quickly Field Adjustable
All PowerMaster Recyclones™ are quickly and easily air wrench adjustable to produce finished sized materials from inches down to microns.

9. Intake Size
The intake opening of the PowerMaster is 3' H. x 2' W. x 5' L.. Large objects that barely fit into the machine are usually easily taken and reduced. The PowerMaster will accept rough sized rock up to about an average 20" overall size as feed material. Broken concrete slab that will feed into the opening is easily reduced.

10. Unparalleled 1 to 3 Year Warranties
Americana warrants to the original buyer that the PowerMaster Recyclone is free of defects in parts, materials and workmanship under normal usage and with proper maintenance, from the date of the acceptance certificate.
PEG is proud of the Power Master's high design and manufacturing standards and is pleased to provide PowerMaster customers with the best warranties in the industrial processor business.

MODEL RECYCLONE	200	300	400
Capacity Examples (tph)			
MSW	20	50	80
Food Waste	50	120	350
LimeStone	100	200	300
Wood Waste (ctl / dense)	100	200	300
Soil Components	40	80	120
Weight, Lbs	14,000 lbs	18,400 lbs	25,900 lbs
Height	150"	150"	150"
Inside Dimensions	72" X 72"	72" X 72"	82" X 82"
CFM Output	8,000-14,000	10,000-25,000	26,000-80,000

Motor - TEFC high torque, 115% efficiency, water & dust proof - 460 volts - 3 phase.
Coatings - Primer + 2 coats industrial enamel - custom coatings / special order.
*Capacity examples can greatly vary according to materials, loading rates, tramp metal, and other factors.
ReCyclones from 200 to 400 HP are built in three models based on categories of service:

Table 4.3.3.2. Technical specification of grinding unit

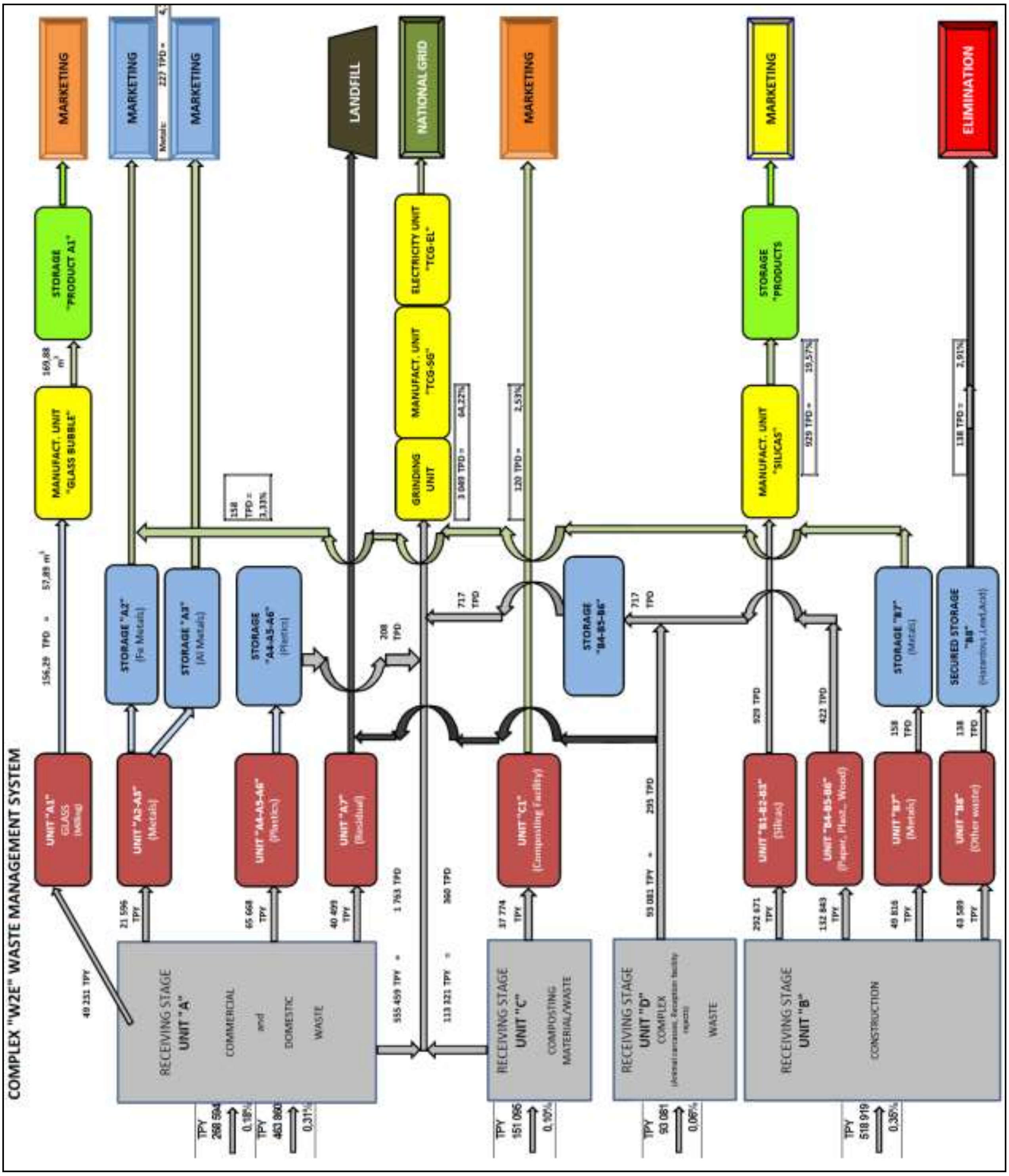


Figure 4.3.3.3. Material Flow chart of the Pre-selecting Unit
(Ref. Tender documentation 5.6.)

Considering the requested pre-selecting categories above and the area requirements of the pre-selection lines, the following AUXS 1 Unit was designed.

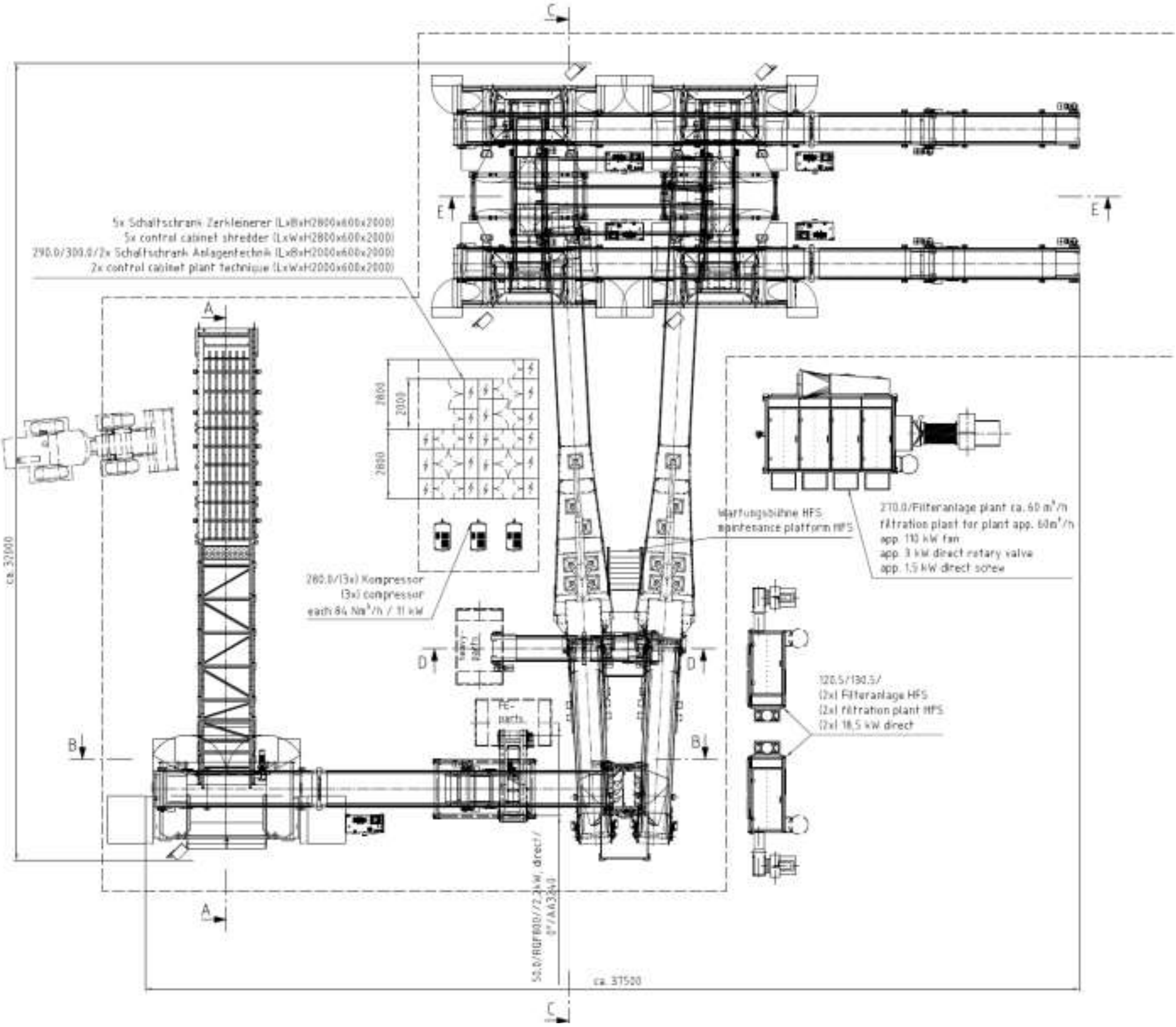


Figure 4.3.3.4. Overview of the equipment of Pre-selection Plant

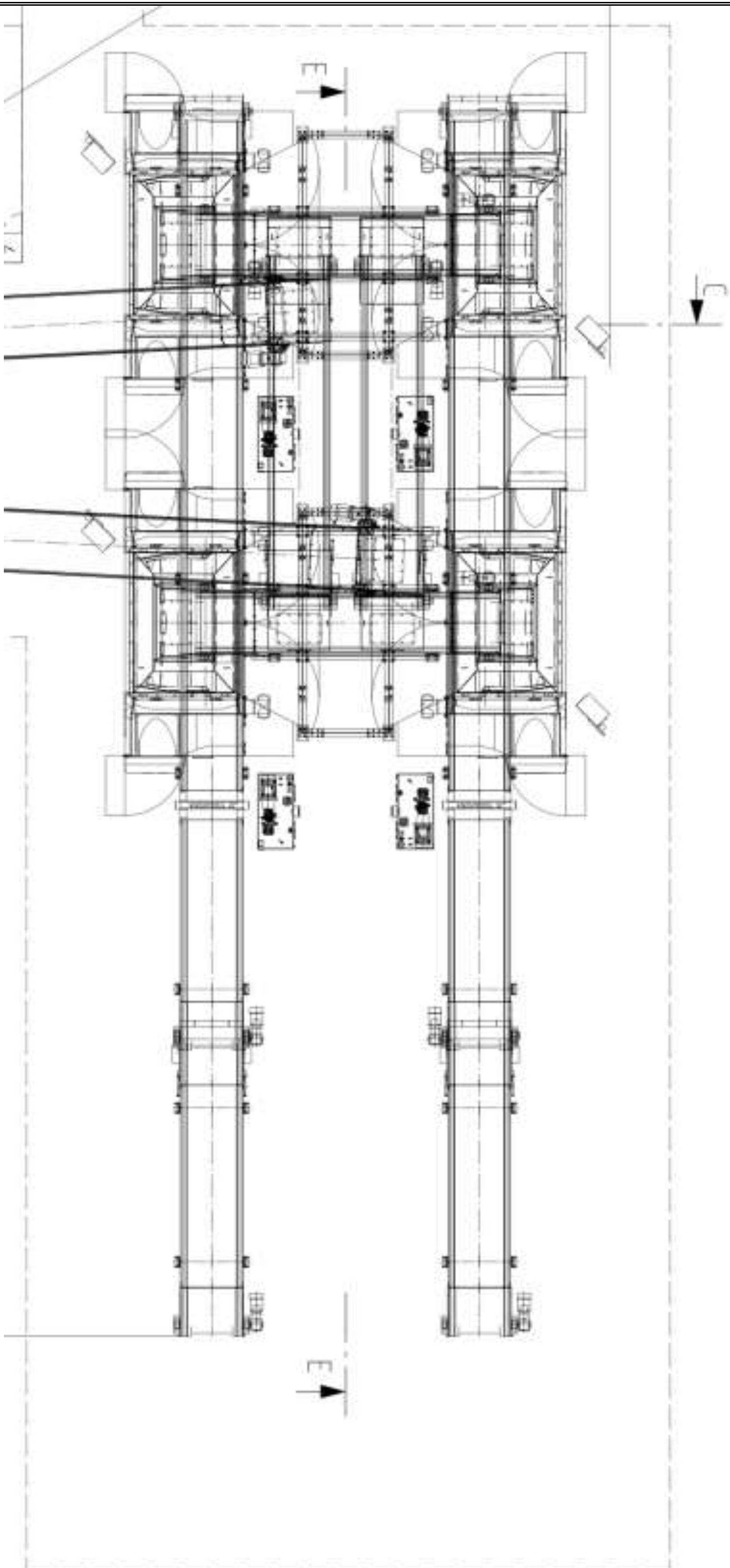


Figure 4.3.3.5. Sub Unit 1 of the Pre-selecting Unit

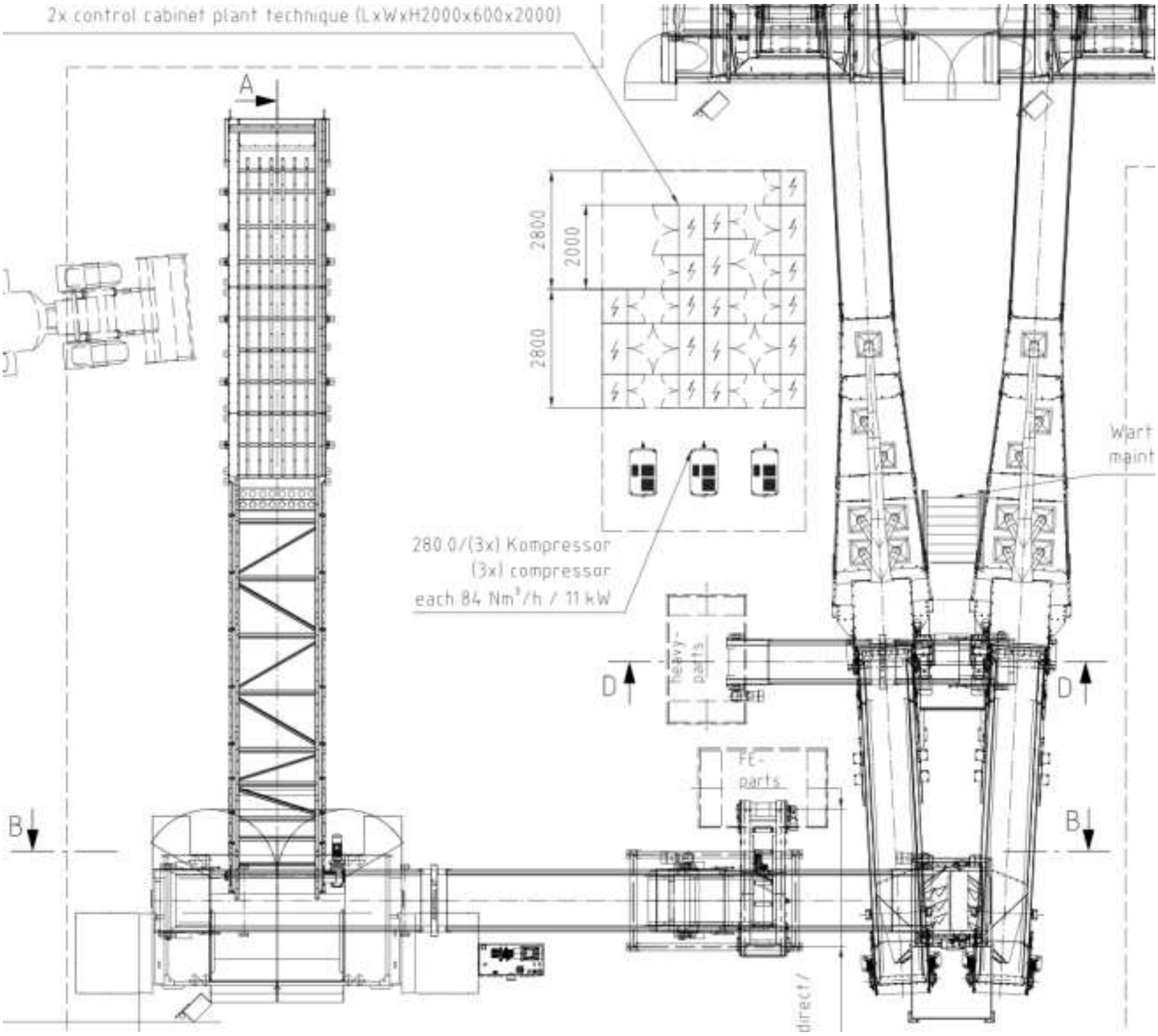


Figure 4.3.3.6. Sub Unit 2 of the Pre-selecting Unit

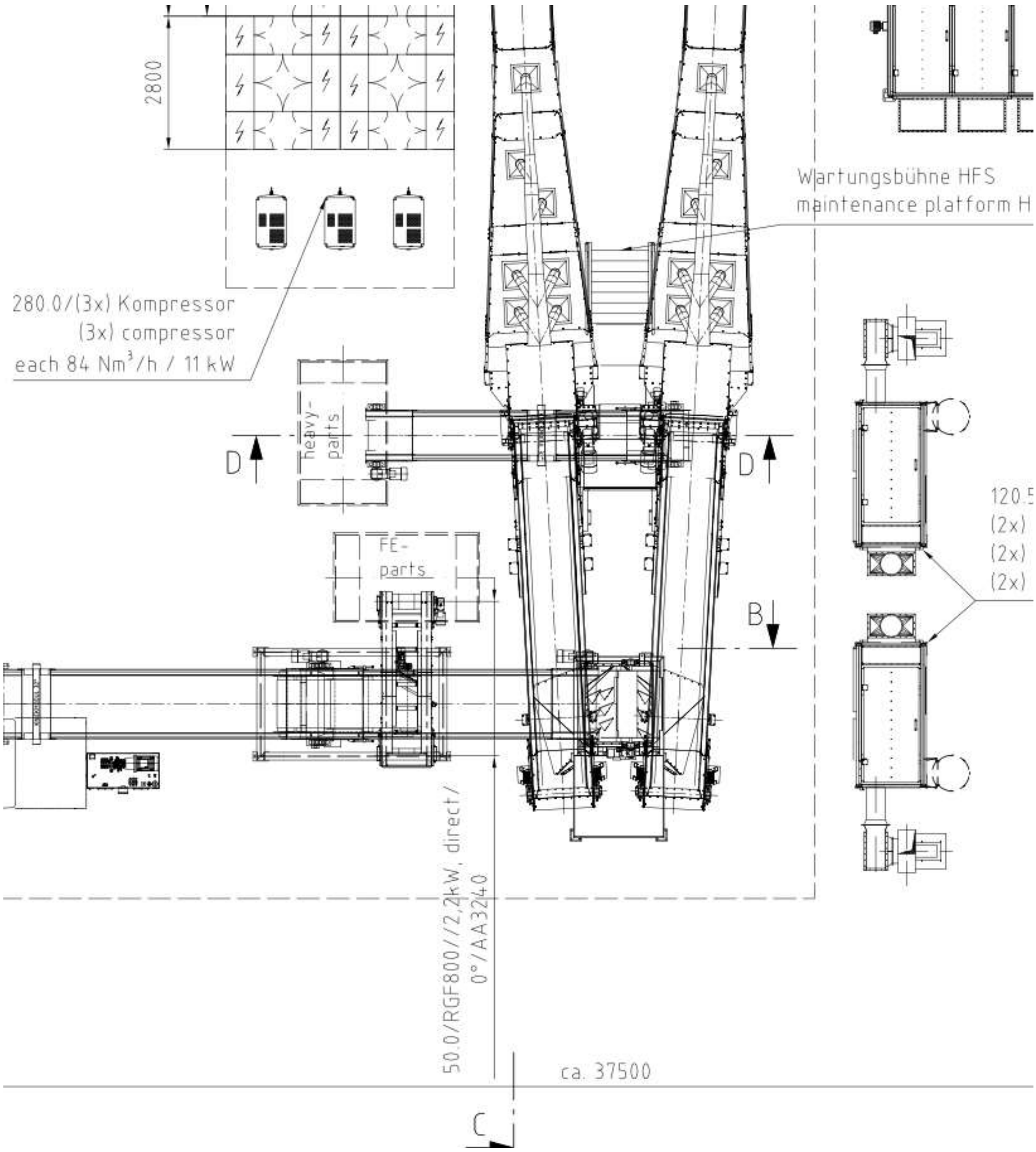


Figure 4.3.3.7. Sub Unit 3 of the Pre-selecting Unit

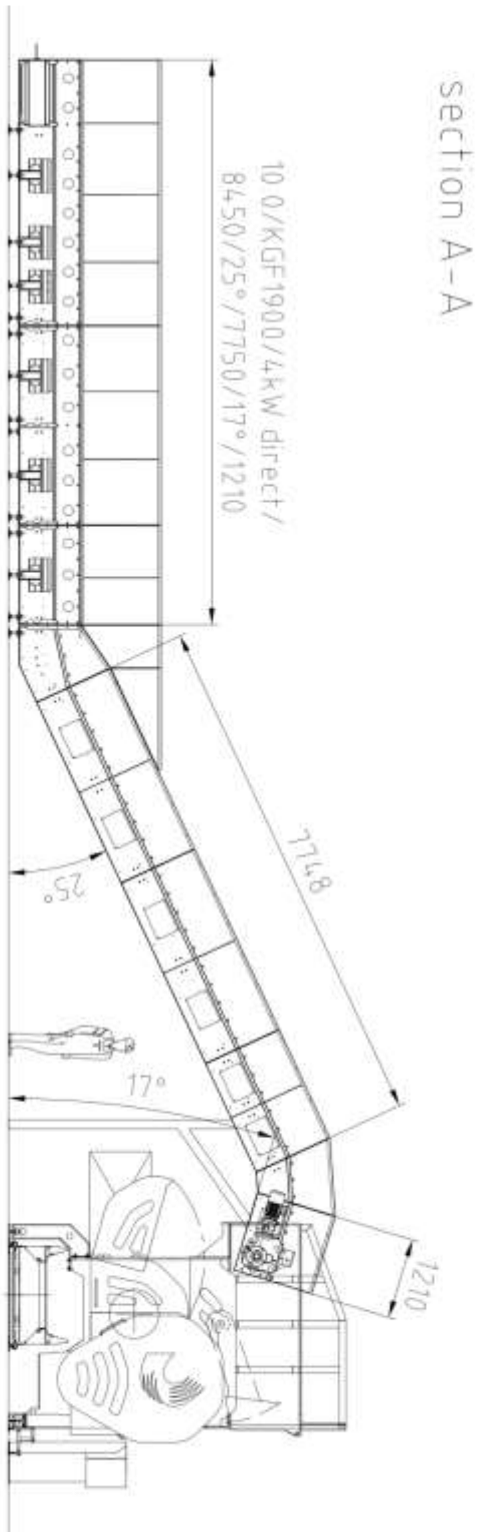


Figure 4.3.3.8. Section A-A

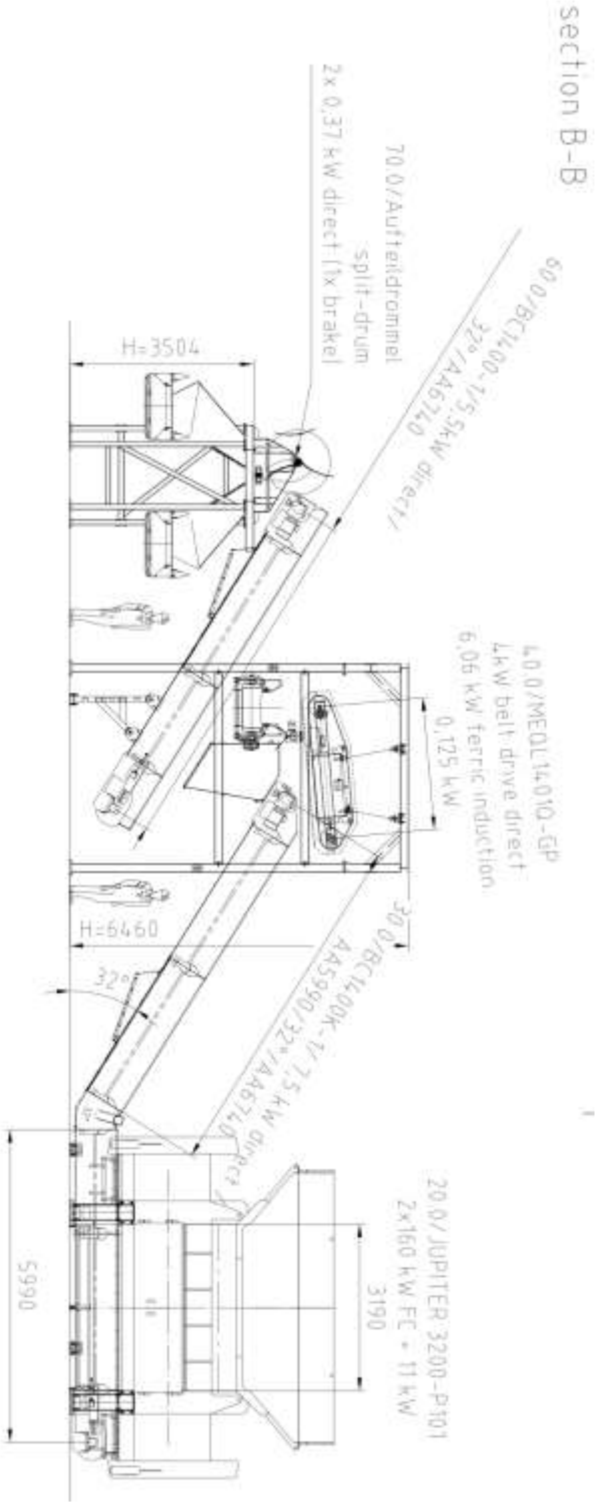


Figure 4.3.3.9 Section B-B

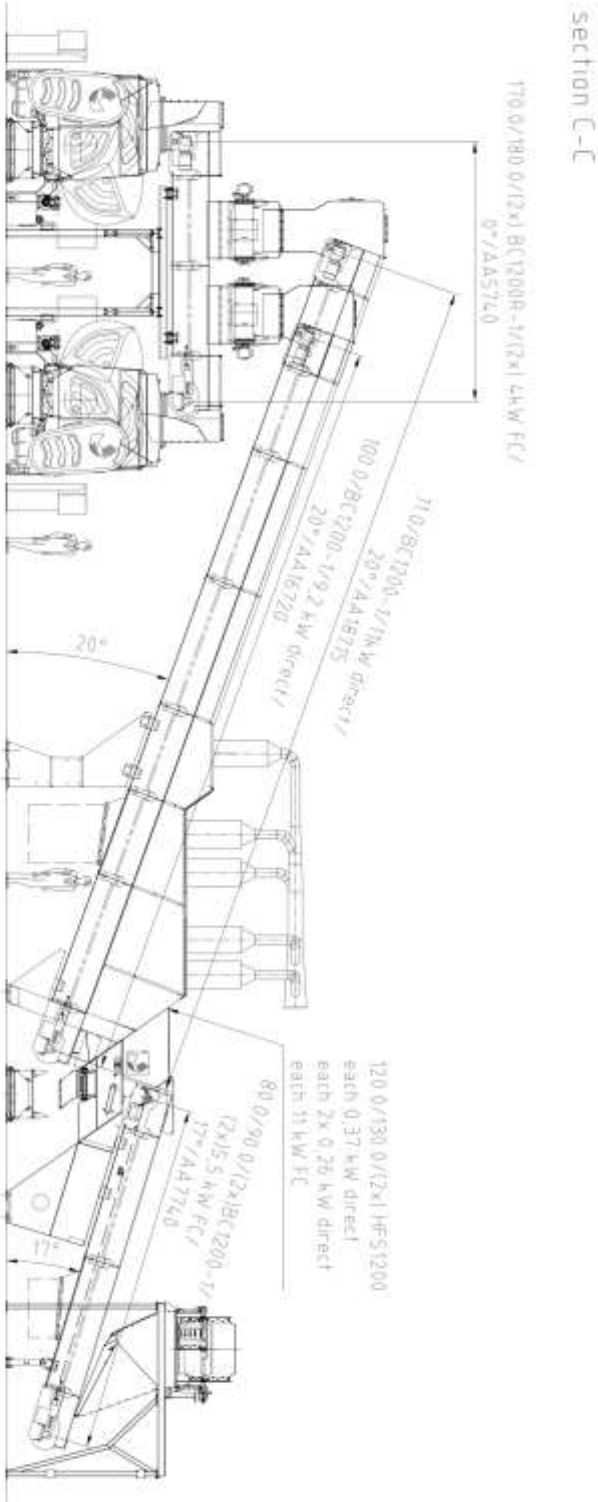


Figure 4.3.3.10. Section C-C

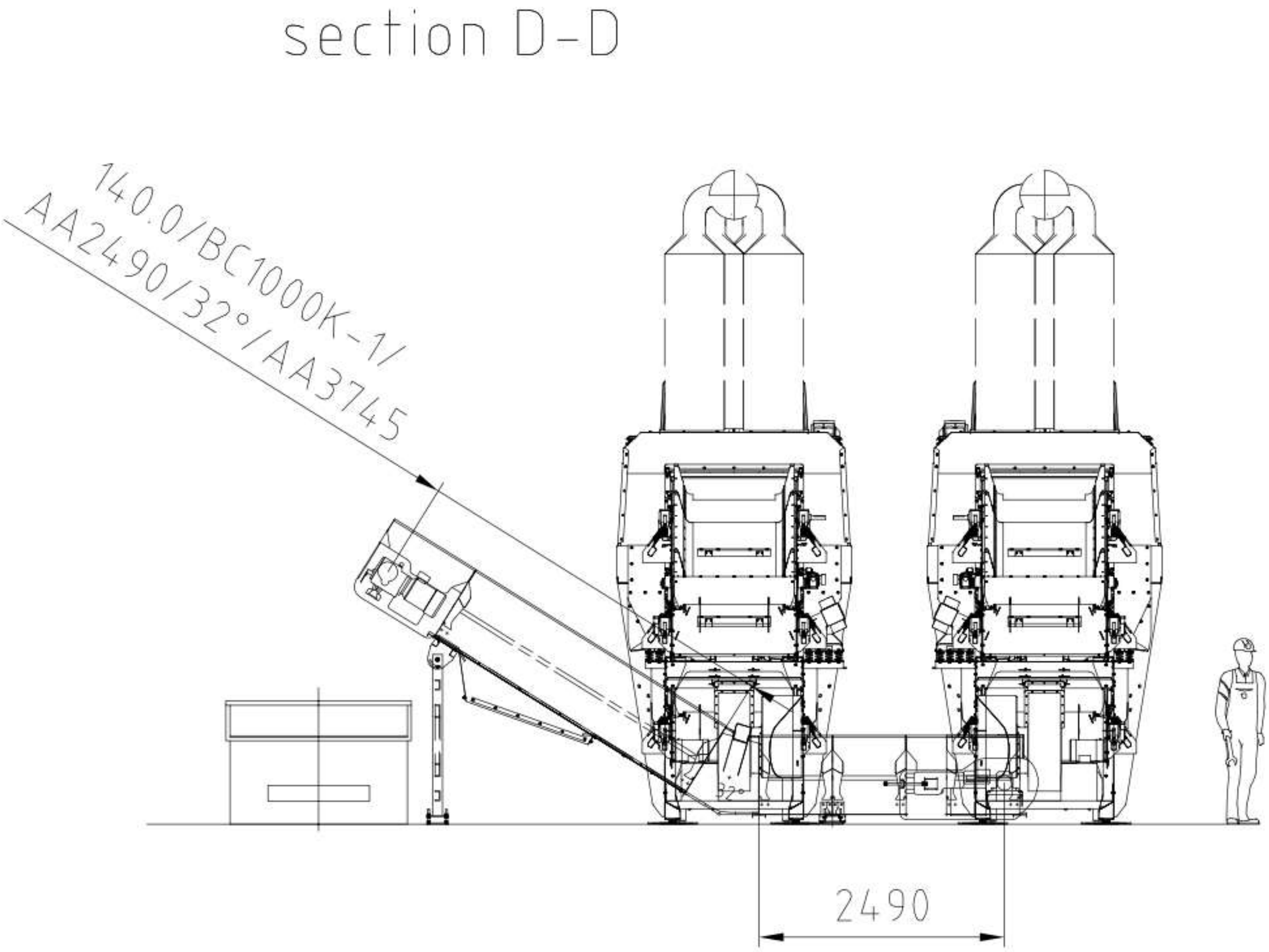


Figure 4.3.3.11. Section D-D

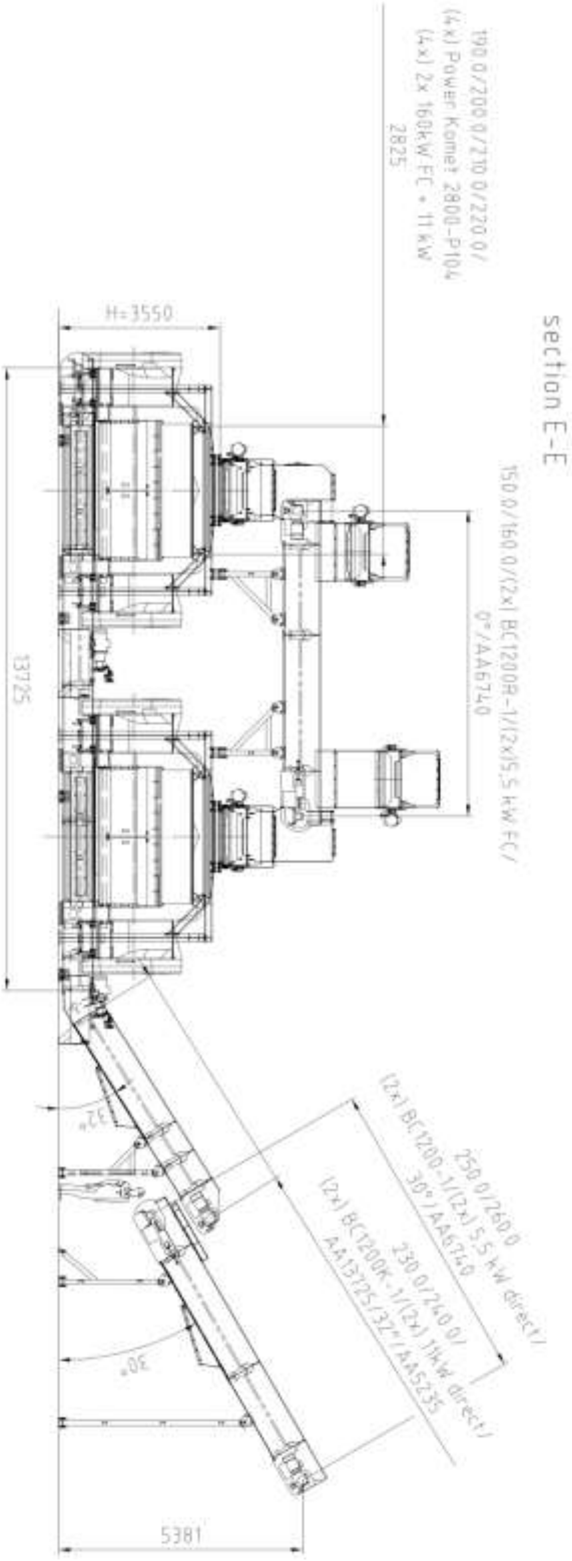
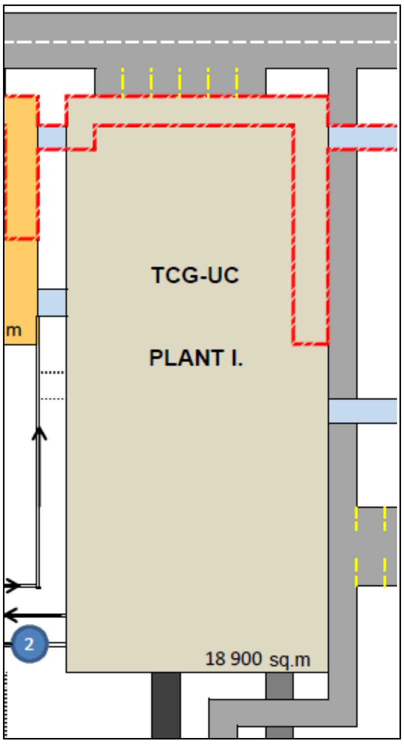


Figure 4.3.3.12. Section E-E

Figure 4.3.3.13. The location of the Pre-Selection Plant.

4.3.4. The location of the syngas manufacturing



One, 500 TPD input side capacity TCG Unit produces 492.385m^3/d quantity syngas with a 12.663kJ/m^3. Considering the total quantity of MSW Feedstock, the TCG-UC Unit consists of 6+1, 500TPD capacity TCG Units.

Although the TCG Unit was designed for a 24 hours a day and 7 days a week continuous operation it has to be secured with „hot spare".

In case of any technical problem or the maintenance of any TCG Unit, the „hot spare" Unit can be swithed on and operated as substitute. This is the seventh TCG Unit planned.

Figure 4.3.4.1. The TCG-UC Plant I.

The produced 6 x cca. 20,21 MWe electricity can be uploaded to the National Electricity Grid (NEG) through the Al Dur Power Plant, and its connection point.

4.4. Input/feed material

The basic parameters of the MSW were provided by the issuer in the tender document.

Assumed Material Compositions of different Waste Streams

	Construction %	Domestic %	Commercial %
Paper	20.50%	12.79%	38.77%
Glass	3.90%	3.39%	4.94%
Metal	9.60%	2.05%	4.50%
Plastic	5.10%	7.44%	11.60%
Other Organic	0.00%	68.73%	26.59%

Inert	56.40%	0.00%	7.77%
Household Hazardous Waste	0.20%	0.19%	0.33%
Special Waste	4.10%	0.00%	4.54%
Mixed Residue	0.20%	5.40%	0.97%
TOTAL	100.00%	100.00%	100.00%

Table 4.4.1. The Waste Streams (by tender docs)

YEARLY 'TONNAGE ALL' REPORT FROM 2008 TO 2013

YEAR	DEAD ANIMAL	BUILDING WASTE	COMMERCIAL WASTE	DOMESTIC WASTE	GARDEN WASTE	INDUSTRIAL WASTE	TOTAL
2008	15329.3	617951.2	445508.2	380871.2	120189.1	65656.0	1,645,505
2009	16570.5	570455.8	320432.4	402241.2	149153.1	73672.6	1,532,526
2010	11643.4	528712.5	287511.1	457335.5	173128.4	87994.7	1,546,326
2011	9785.3	534473.5	247013.1	430836.1	117613.1	83566.9	1,423,288
2012	10585.02	476163.1	271245.9	444801.2	133999.7	95235.1	1,432,030
2013	9063.9	518919.4	268594.3	463859.7	151094.7	84016.8	1,495,549

Table 4.4.2. The Waste Streams (by tender docs)

MONTHLY TONNAGE BY PRODUCT TYPE
YEAR - 2013

MONTH	DOMESTIC	COMMERCIAL	BUILDING WASTE	INDUSTRIAL	GARDEN	DEAD ANIMAL	TOTAL
	TONS	TONS	TONS	TONS	TONS	TONS	TONS
JANUARY	37194.2	23822.3	62263.1	9101.8	12364.9	317.8	145064.1
FEBRUARY	33212.8	20426.3	51875.1	7799.3	9704.4	201.2	123219.1
MARCH	38237.6	22507.9	37543.4	9286.7	12158.4	184.0	119917.8
APRIL	37651.4	23096.0	37850.9	7325.1	14025.4	197.5	120146.2
MAY	39718.0	22087.2	35328.1	7251.2	13444.2	594.6	118423.2
JUNE	39294.2	21494.5	34000.4	6672.8	12223.5	781.6	114467.1
JULY	42003.8	20554.7	31650.0	5787.6	10597.5	1389.9	111983.4
AUGUST	39211.3	22244.0	41520.3	5303.2	11417.1	1318.6	121014.5
SEPTEMBER	38088.7	24731.0	35316.2	5303.4	13743.3	1217.0	118399.6
OCTOBER	39422.0	23657.8	50647.5	5038.4	13811.6	1293.8	133871.2
NOVEMBER	40207.1	20600.6	57990.1	5973.6	12918.2	820.6	138510.2
DECEMBER	39618.6	23372.1	42934.1	9173.9	14686.3	747.4	130532.4
TOTAL	463859.7	268594.3	518919.4	84016.8	151094.7	9063.9	1495548.7

Table 4.4.3. Monthly tonnage product type in 2013

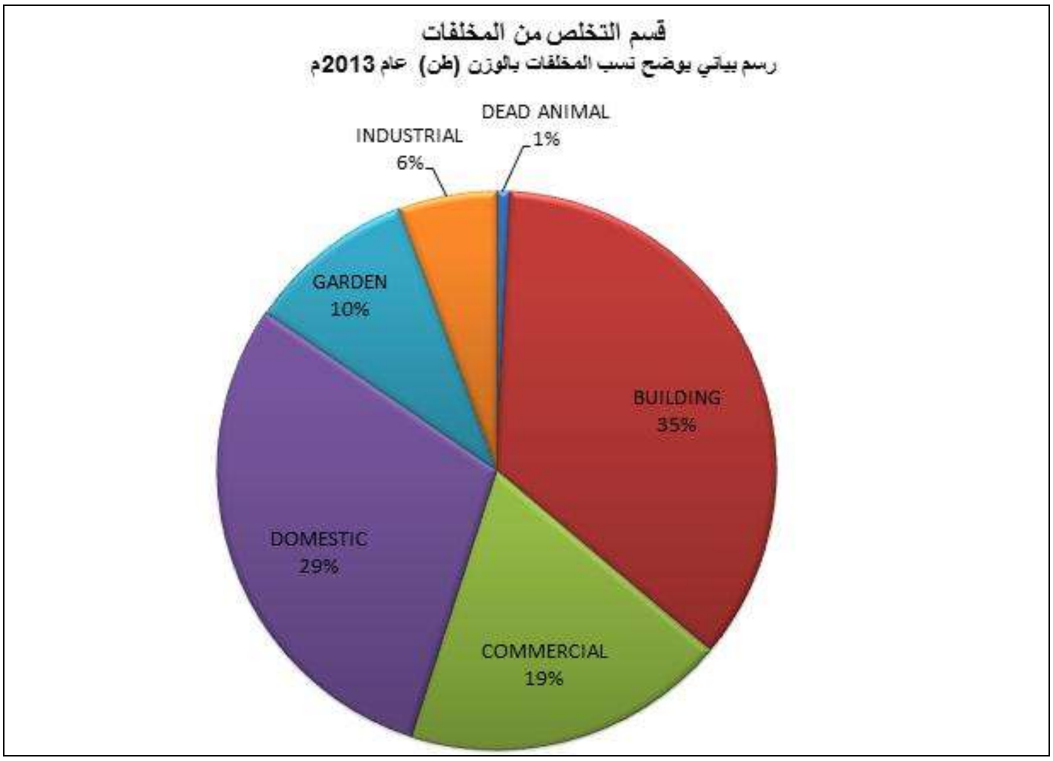


Figure 4.4.1. The sources of the MSW

Supplier: Sub-contractor with appropriate permits.

4.5. The end/required product (s)

4.5.1. Electricity

Declaration concerning the purchase of the electric energy and of the agreement and arrangement of the connection to the local or national electricity grid. The organic (carbonaceous) wastes can be used as feedstock in the TCG Units. Generating a standard quality syngas that can be led into the GTE (Gas To Electricity) Unit the electric energy and heat energy are produced. Considering both the above quality and quantity of organic wastes and the requirement of the tender document the following end product can be generated.

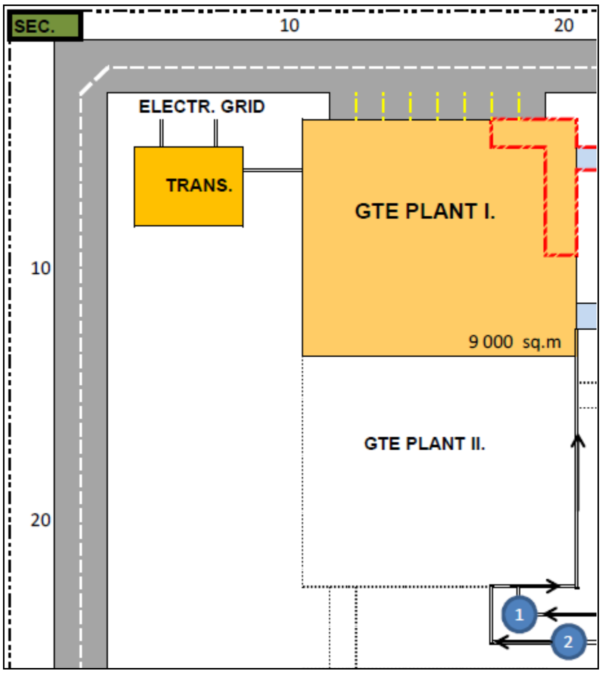


Figure 4.5.1.1. The GTE Plant (s)

Using the above described MSW, a 500TPD feedstock capacity TCG plant and the GTE unit can produce 20,21MWe electricity and 56,38 GJ heat energy **hourly**.

Altogether the one Unit – consisting of one 500TPD capacity TCG Unit and one GTE Unit - will produce:

485,04 MWeh electricity and 1.353,0 GJ thermal energy **daily**, consequently

151.342 MWeh and 422.245 GJ **yearly**.

Considering the expectable growing of the quantity of the waste, the capacity of the units designed into the sites, can be extended to 3 million TPY, as it was requested in the tender documentation. The "GTE PLANT I" established in the first stage, can produce the above quantity of both electric and thermal energy. The "GTE PLANT II." will be established and operated if the daily quantity of the waste, and - due to this – the generated quantity of syngas exceed the capacity of the "GTE PLANT I.".

As it can be seen in the above figure, two, temporary storage tanks (two, white numbered, blue circles) were designed securing and storing the requested quantity of syngas for heating up the "Hot Spare" TCG unit, if it is needed.

4.5.1.1. The connection/discharging points for the end product(s)

The electricity can be led into the national grid through the transformator unit established between the left side borderline and the GTE PLANT I in the North site. The technical environment and the requested parameters of the electricity will be determined by the Al Dur Power Plant, and the national electricity service provider.

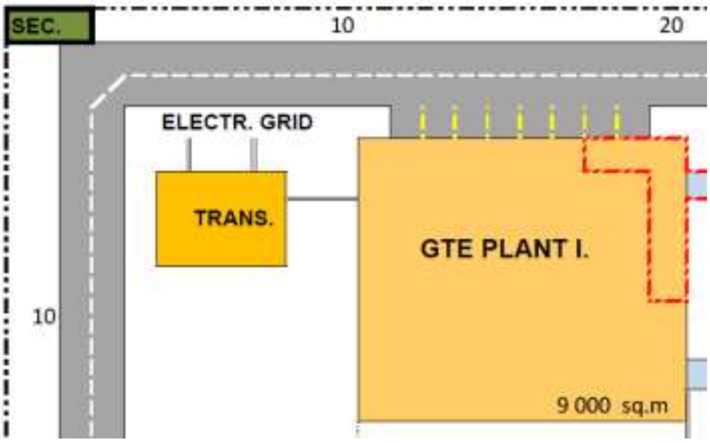


Figure 4.5.1.1.1. The Transformator station and the GTE Plant I.

4.5.1.2. Capacity Al Dur 220kV-Power Line

Figure 4.5.1.2.1. Al Dur Power & Water Plant

Electricity production (Source: carma.org)

MWh	year
0.0	2000
0.0	2007
4,141,090.00	2020

Emissions

name	emissions_kg	year
Carbon Dioxide	0.0	2000
Carbon Dioxide	0.0	2007
Carbon Dioxide	1,815,270,000.00	2020

Al Dur

Location: Bahrain
Operator: Al-Dur Power & Water Co
Configuration: two 668-MW CCGT blocks with 9001FA gas turbines, desalination
Fuel: natural gas, oil
Operation: 2010-2012
HRSG supplier: Hyundai
T/G supplier: GE
EPC: Hyundai
Quick facts: On 1 May 2012, King Hamad Bin Isa Al-Khalifa inaugurated Bahrain's largest independent power generation and water desalination plant. Two of the gas turbines went into simple-cycle operation in 2010 and the facility began full commercial operation in Feb 2012. Desal capacity is 218 000 ³. In total, the plant can supply about one-third of the Kingdom's water and power supply. Bahrain Electricity and Water Authority (EWA) is the sole off-taker of the plant output under a 25yr PPA. Al Dur cost $2,1bn and is owned by a consortium of International Power-GDF SUEZ and Gulf Investment Corp.

4.5.1.3. Electric energy to be uploaded

Figure 4.5.1.3.1. Electrical connection point of Al Dur Power & Water Plant

4.5.1.4. The owner/operator of the connection point

The owner (s) or operator of both the networks and connecting points.

(NAP)

4.5.1.5. Predicted costs of the connection points

The operator of the grid or network should provide the costs according to the location of the connection points and the quantity of the injected energy.

4.5.2. The utilization of the thermal energy

The requested information should be calculated as the average value of the last five years. The average temperature of the forward flowing (injected) water is 95 °C in winter and 65 °C in the summer. (NAP)

4.5.2.1. Map of the connecting points

The expences of the Connecting Unit – the transformators and the security systems – can be calculated according to the environmental and the requirements of the operator of the national grid where we have to connect our point. (NAP)

4.5.2.2. Capacity

The quantity of the maximum energy that can be injected into the system.

Number of TCG Unit	Quantity of Used Feedstock	Electricity (MWe)	Heat Energy (GJ)
1 Unit Daily	514 TPD,	485,04 MWeh	1.353,12 GJ
6 Units Daily	3.086 TPD,	2.909,76 MWeh	8.118,24 GJ
6 Units, Yearly	963.089 TPY	908.087 MWeh	2.533.567 GJ

Table 4.5.2.2.1. Specefic data of the plant

4.5.2.3. Operator

The operators of the networks and the connecting points.

4.5.2.4. Predicted costs of the connection

The network operator will provide this information that is the function of the location of the connecting points and the maximum injectable energy.
The operator of the grid or network should provide the costs according to the location of the connection points and the quantity of the injected energy. (NAP)

(These information will be officially provided in the Feasibility study)

4.5.3. Possible utilization (I.) of thermal energy in industry such as (Glass-foam pebble as insulator)

The information/value should be calculated as the average of the last 5 years.
The average temperature of the forward flowing (injected) water is 95 °C in winter and 65 °C in summer.

(These information will be officially provided in the Feasibility study)

4.5.3.1. Foam-pebble (glass-pebble) technology

The thrust of this environmental friendly technology is to utilize industrial and municipal waste glass to manufacture valuable semi-ready, base and special materials/products for the building and construction industries. This special material/product can be used as mortar/plastering, as a heat and sound insulator, chemical isolation rolled steel, as building material for special concrete, ceiling floor or boards, parting walls and many other applications.

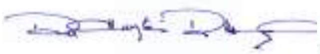
„Glass-Foam Bubbles" or glass-pebbles are manufactured as granulate from high glass content waste or glass waste. The waste glass that is grounded to appropriate size mixed with special base material and inflating agent and well homogenized. The manufacturing process or otherwise the granulation is controlled with the addition of material for reducing the melting-temperature and material for controlling the viscosity. The outer surface of the granulars is treated with different waste materials having different unit surface that will control the permeability (water transmissibility) of the manufactured glass pebbles or granulars. The raw or freshly produced glass-pebbles or granulars will be heat treated and dried in a specially designed rotary dryer. The manufactured glass–pebbles or granulars have low density (body-density), their required size (diameter) can be set from 2mm to 25mm, they exhibit excellent heat and sound isolation property, and they adhere well to gypsum, cement, and silicate-wax. See Figure 6.

Figure 4.5.3.1.1. The manufactured "glass-foam" or glass-pebbles.

4.5.3.2. Capacity

The capacity of the Glass Bubble Plant will be determined based ont he maximum energy that can be injected into the system.

(These information will be officially provided in the Feasibility study)



4.5.3.3. The developer and supplier of the technology

(These information will be officially provided in the Feasibility study)

4.5.3.4. Predicted income and operating costs

(These information will be officially provided in the Feasibility study)

4.5.4. Possible utilization (I.) of thermal energy in industry such as (Decor stones and bricks manufacturing plant)

Having regard to the circumstances the heat energy will have to be used in several manufacturing systems, producing different marketable products.

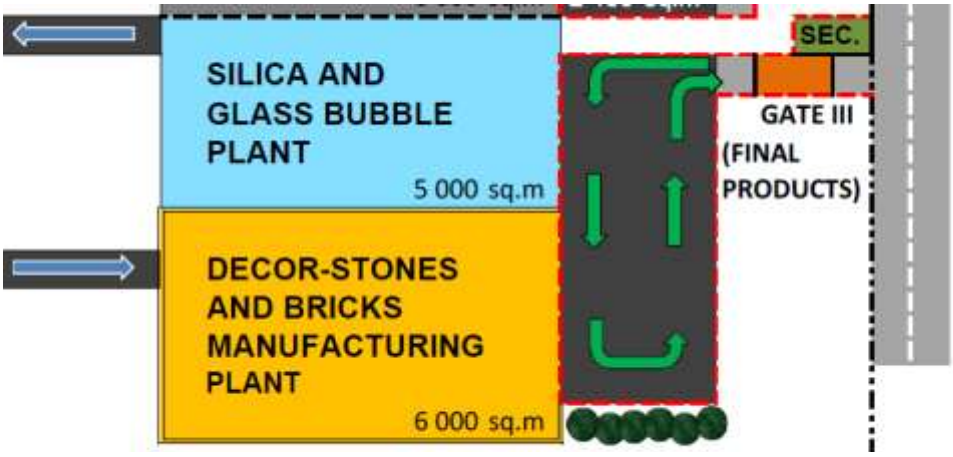


Figure 4.5.4.1. The application of heat energy in manufacturing systems

The pre-selected glass waste (plate glass, laminated glass, container glass, and other clean SiO_2 materials) can be used as feedstock in the "Silica and Glass Bubble Plant" manufacturing SiO_2 foam balls, that are very effective heat-insulating additives and can be applied in several fields of manufacturing from the agricultural till the construction business.

The "Decor-Stones and Brick Manufacturing Plant" is established to use the other silica and inorganic materials (sand, grinded brick and concrete, and the ash of the TCG Plant) as feedstock to the manufacturing of decorative stones, the breakwater elements and other products.

Figure 4.5.4.2. és 4.5.4.3. Decorative stone pavements

These breakwater elements can stabilize the sea shores and can provide a stable basis of the (new) artificial islands.

Figure 4.5.4.4. és 4.5.4.5. Breakwater elements

Figure 4.5.4.6. Bahrain Bay Artist Impression

4.6. The Man Power of project

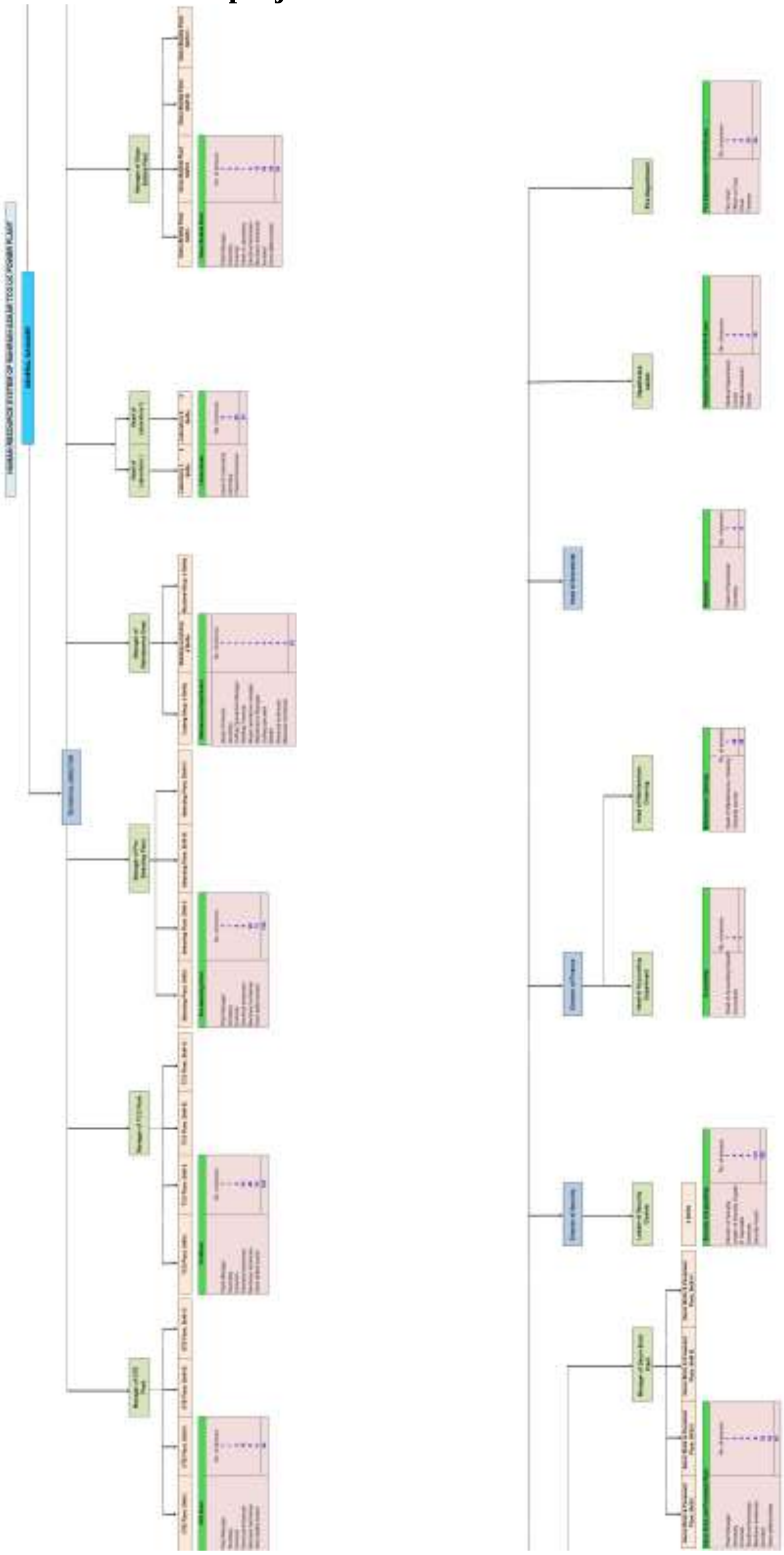
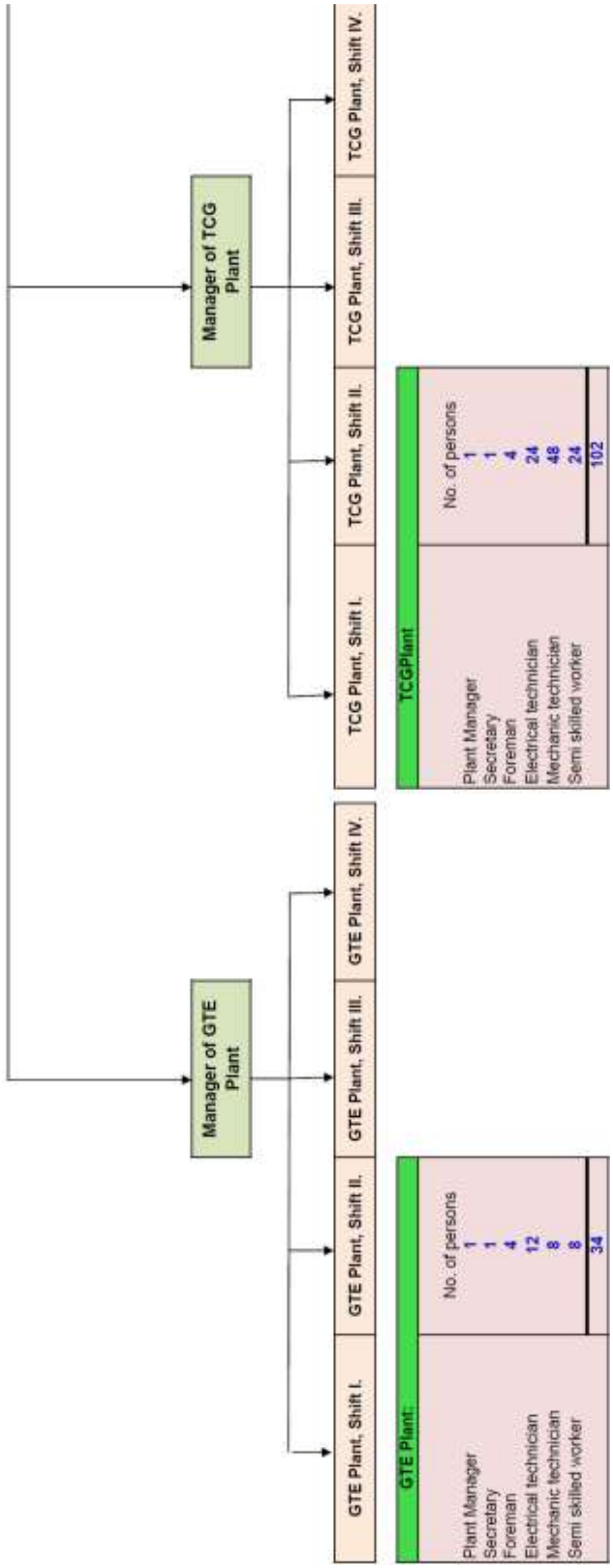
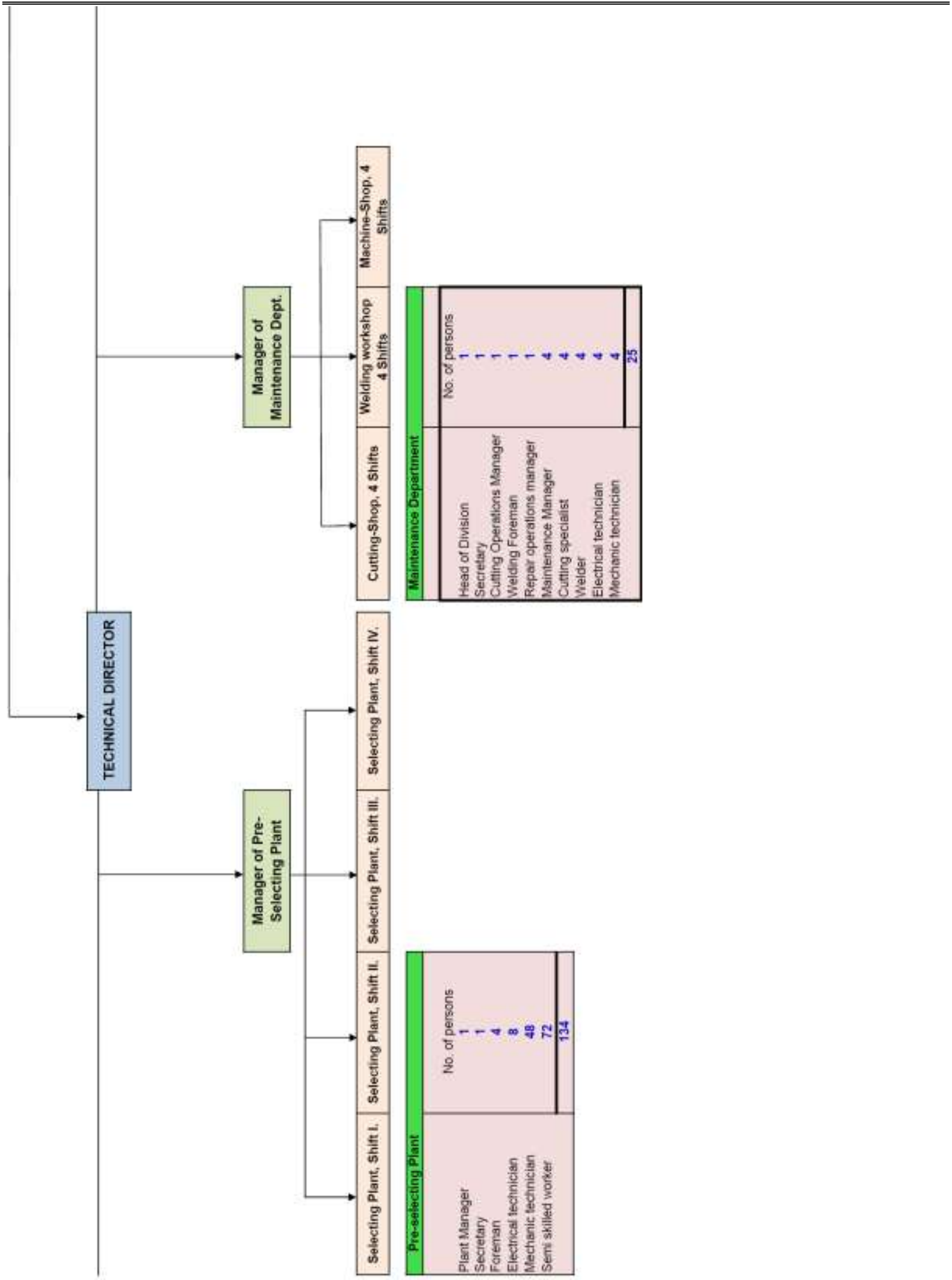


Figure 4.6.1.



Manager of GTE Plant
Manager of TCG Plant
GTE Plant, Shift I.
GTE Plant, Shift II.
GTE Plant, Shift III.
GTE Plant, Shift IV.
TCG Plant, Shift I.
TCG Plant, Shift II.
TCG Plant, Shift III.
TCG Plant, Shift IV.
GTE Plant:
No. of persons
Plant Manager 1
Secretary 1
Foreman 4
Electrical technician 12
Mechanic technician 8
Semi skilled worker 8
34
TCGPlant
No. of persons
Plant Manager 1
Secretary 1
Foreman 4
Electrical technician 24
Mechanic technician 48
Semi skilled worker 24
102

Figure 4.6.2.



TECHNICAL DIRECTOR
Manager of Pre-Selecting Plant
Manager of Maintenance Dept.
Selecting Plant, Shift I.
Selecting Plant, Shift II.
Selecting Plant, Shift III.
Selecting Plant, Shift IV.
Cutting-Shop, 4 Shifts
Welding workshop 4 Shifts
Machine-Shop, 4 Shifts
Pre-selecting Plant
No. of persons
Plant Manager 1
Secretary 1
Foreman 4
Electrical technician 8
Mechanic technician 48
Semi skilled worker 72
134
Maintenance Department
No. of persons
Head of Division 1
Secretary 1
Cutting Operations Manager 1
Welding Foreman 1
Repair operations manager 1
Maintenance Manager 4
Cutting specialist 4
Welder 4
Electrical technician 4
Mechanic technician 4
25

Figure 4.6.3.

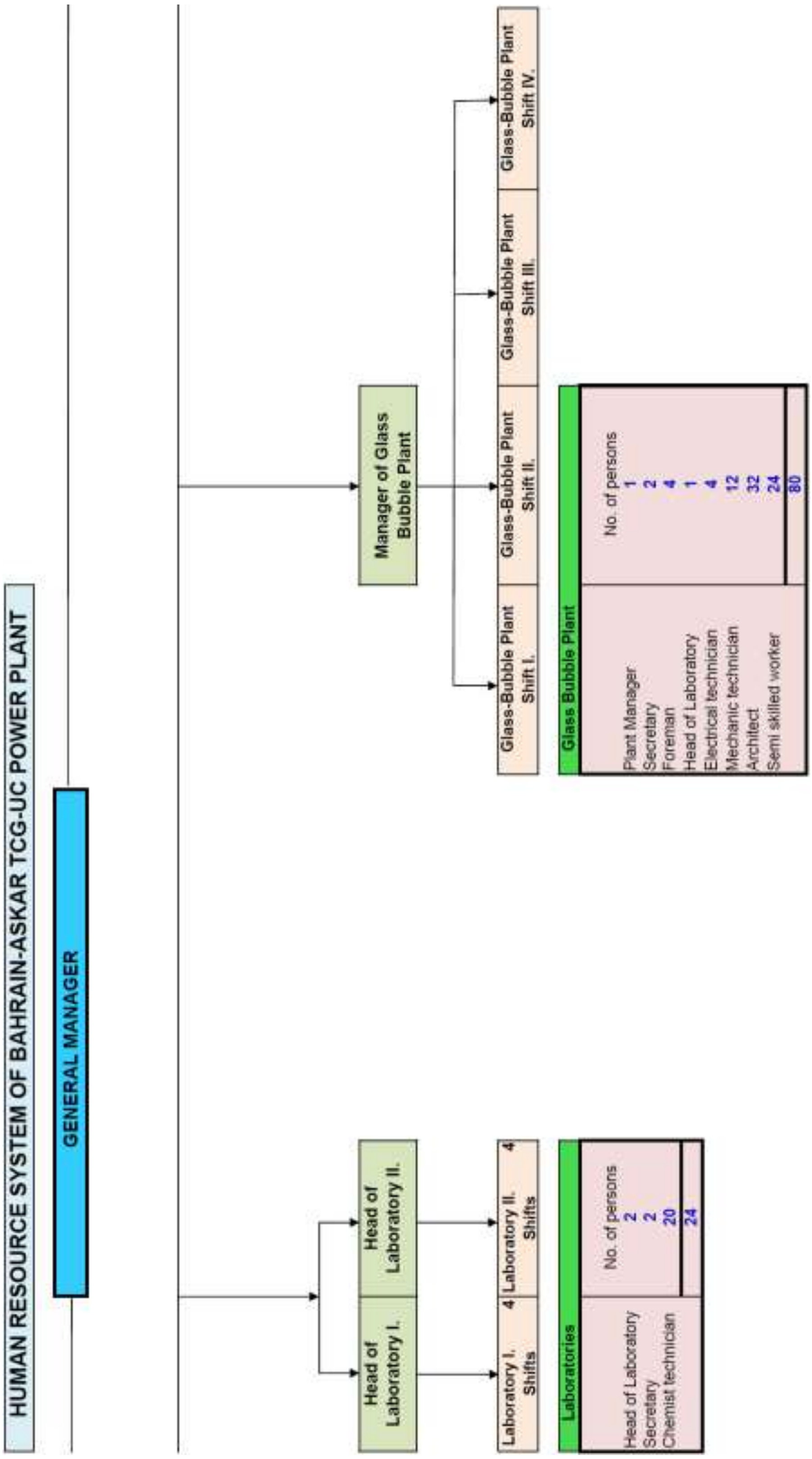

HUMAN RESOURCE SYSTEM OF BAHRAIN-ASKAR TCG-UC POWER PLANT
GENERAL MANAGER
Head of Laboratory I.
Head of Laboratory II.
Manager of Glass Bubble Plant
Laboratory I. Shifts 4
Laboratory II. Shifts 4
Glass-Bubble Plant Shift I.
Glass-Bubble Plant Shift II.
Glass-Bubble Plant Shift III.
Glass-Bubble Plant Shift IV.
Laboratories
No. of persons
Head of Laboratory 2
Secretary 2
Chemist technician 20
24
Glass Bubble Plant
No. of persons
Plant Manager 1
Secretary 2
Foreman 4
Head of Laboratory 1
Electrical technician 4
Mechanic technician 12
Architect 32
Semi skilled worker 24
80

Figure 4.6.4.

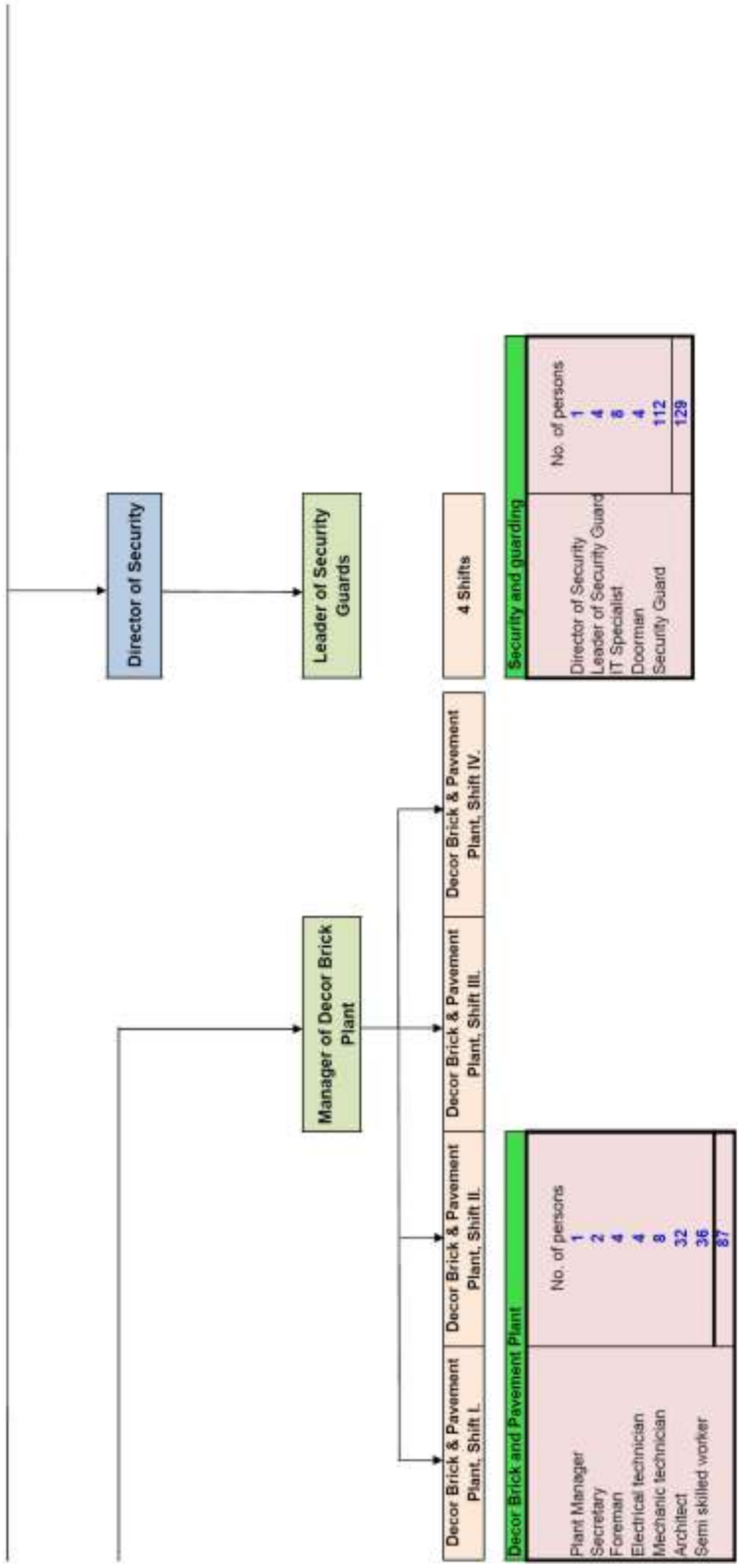
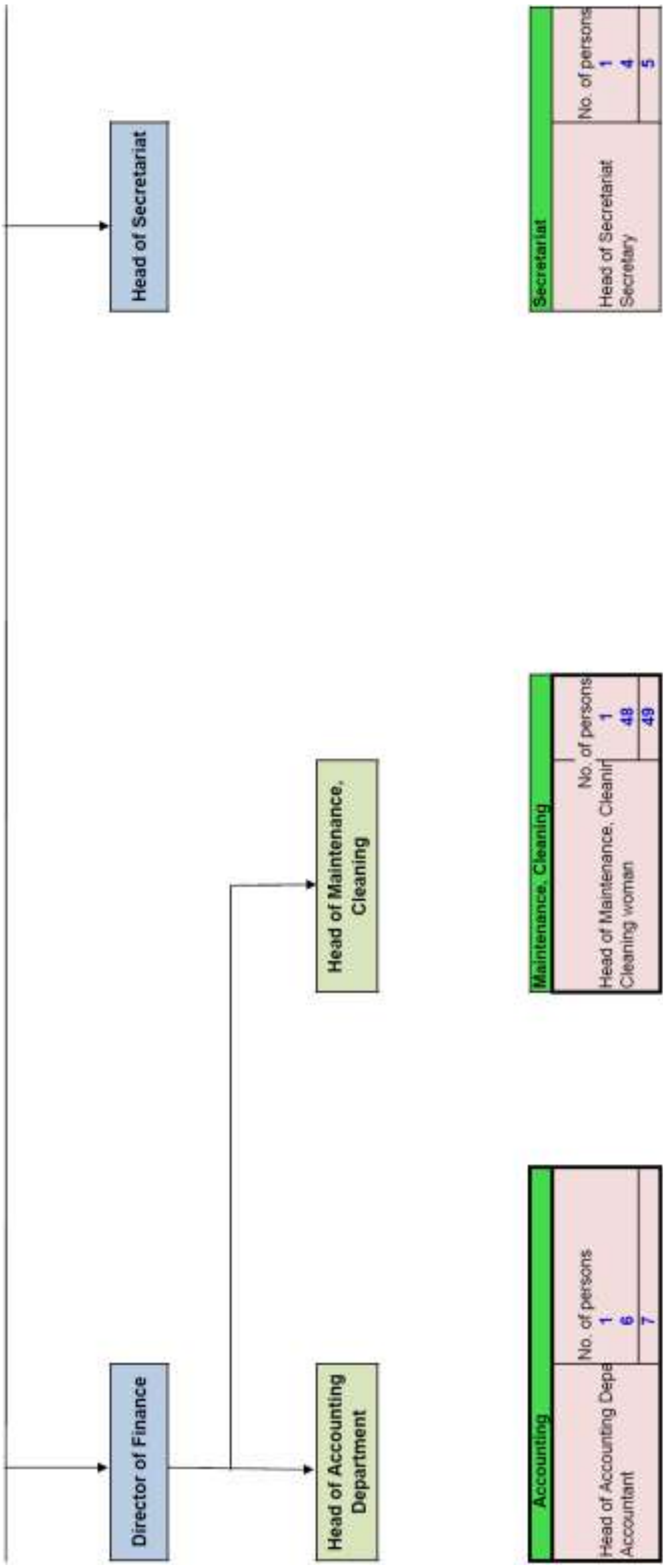
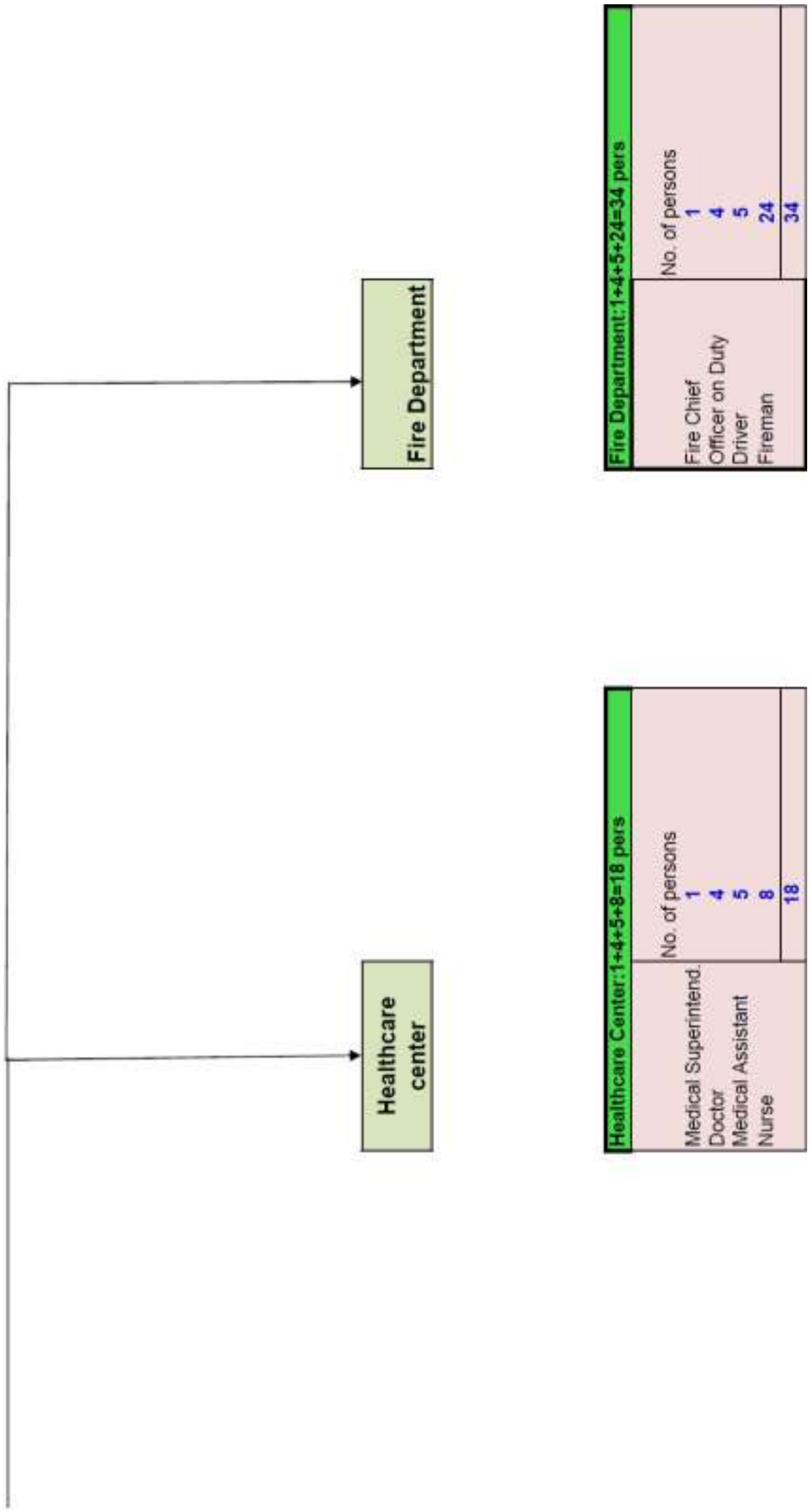

Director of Security
Leader of Security Guards
4 Shifts
Security and guarding
Director of Security
Leader of Security Guard
IT Specialist
Doorman
Security Guard
No. of persons
1
4
8
4
112
129
Manager of Decor Brick Plant
Decor Brick & Pavement Plant, Shift I.
Decor Brick & Pavement Plant, Shift II.
Decor Brick & Pavement Plant, Shift III.
Decor Brick & Pavement Plant, Shift IV.
Decor Brick and Pavement Plant
Plant Manager
Secretary
Foreman
Electrical technician
Mechanic technician
Architect
Semi skilled worker
No. of persons
1
2
4
4
8
32
36
87

Figure 4.6.5.



Director of Finance
Head of Accounting Department
Head of Maintenance, Cleaning
Head of Secretariat
Accounting
No. of persons
Head of Accounting Depa 1
Accountant 6
7
Maintenance, Cleaning
No. of persons
Head of Maintenance, Cleanir 1
Cleaning woman 48
49
Secretariat
No. of persons
Head of Secretariat 1
Secretary 4
5

Figure 4.6.6.



Fire Department
Healthcare center
Fire Department:1+4+5+24=34 pers
No. of persons
Fire Chief 1
Officer on Duty 4
Driver 5
Fireman 24
34
Healthcare Center:1+4+5+8=18 pers
No. of persons
Medical Superintend. 1
Doctor 4
Medical Assistant 5
Nurse 8
18

Figure 4.6.7.

The modeling procedure consists of the following sub models and calculations:

1. Mass balance model,
    a. Feedstock calculation,
    b. Water calculation,
    c. Ash calculations,

2. Energy balance model,
    a. Input materials,
    b. Middle and final products,

3. Financal model,
    a. Capital expenditures,
    b. Salary and Labor cost,
    c. **Operating Staff,**
    d. Annual operating cost
    e. Annual EBITDA
    f. Yearly Cash Flow for 20 years
4.

3.c. Modeling of Operating staffs of the sub-units of TCG-UC Bahrain Plant:

1. TCG Units,
2. GTE Units,
3. Pre-Selecting Plant
4. Maintenance Department,
5. Laboratories,
6. Glass Bubble Plant,
7. Decor Brick Plant,
8. Security Guard,
9. Accounting Department,
10. Maintenance, Cleaning,
11. Secretariat,
12. Healthcare Center,
13. Fre Department,

****

V. THE TECHNOLOGICAL BASIS OF THE PROJECT

5. Technology

5.1. A brief description of the applied technology for the major units

The essence of the TCG unit is to utilize carbonaceous materials of any type (coal, organic waste, sewage sludge, bio-mass, wood, agricultural waste, municipal solid waste, or their mix, etc.) in a closed, environmentally-friendly system to produce useful material (synthetic gas) that can be through further processing directly or indirectly the feedstock for energy or other useful material generation in a sustainable manner.

The major unit operations of a TCG system:

- **Pre-sorting:** practically most of the carbonaceous materials with the exception glass, metal, rock, soil or silicates are acceptable as a feed material.
- **Breaking/crushing:** the smaller size of the feed material helps to enhance the pyrolysis with better efficiency.
- The appropriately ground carbonaceous material input fed into **the pyrolysis chamber** where under well controlled conditions (380 – 450 ^oC temperature and 10 – 12 bar pressure, and residence time, reduced or no oxygen atmosphere) the input material undergoes **thermo-chemical decomposition,** resulting in charcoal gasses (CO,CO_2, H_2, H_2O CH_4), tar vapor liquids, and solid residue.
- From the pyrolysis chamber, the material is introduced into a proprietary system where the temperature is increased through external heaters and **subjected to steam reforming** in order to produce syngas consisting mostly of hydrogen and carbon monoxide.
- The composition of the synthetic gas is: **H_2; CO; CO_2; CH_4**

5.2. The TCG PLANT

The TCG-UC system, through thermo-chemical process with steam reforming, is capable of converting carbonaceous materials into synthetic gas at app 70% efficiency without emission of harmful solid, gas or liquid materials.   .

5.2.1. Technical background

The Thermo-Chemical Gasification Technology – TCG - allows high temperature thermo chemical gasification without oxygen and air.

It incorporates several new technological developments and design features such as:

- modular construction and shop fabrication;
- no requirement for refractory brick;
- no requirement for separation and injection of oxygen;
- no sensitivity to moisture content in the feedstock;
- no requirement for pulverization or slurry injection of feed;
- flexibility in feedstock alternatives including varying proportions of coal, pet coke, biomass, sewer sludge or other organic waste in different proportions;
- utilization of a unique ionized water treatment system;
- capability of recycling un-reacted carbons back into the reactor chamber, and a near-zero air emissions and liquid discharge.

In addition, some of the carbon dioxide generated in the gasification process can be captured and recycled as feedstock. Further the potential exists to readily integrate this system into a portable, flexible gas-to-liquids bio-refinery. There is substantial commercial potential in the TCG unit.

During the last years, many novel design aspects have been further developed that culminated in a US patent filed on April 11, 2006, application No: 60 / 791,401.

The „TCG-UC System" covers the whole problem area, offering the total solution from the grinding machine, via the TCG Unit, to the „SECU" - SynGas-Electricity energy Conversion Unit (Gas motors or Turbines,) - to the „LFU" - Liquid Fuel Unit (Fischer-Tropsch or other Liquefaction technology) with a specific readily available additional equipment.

A solid carbonaceous material synthesis gas generation plant (gasifier) was built on a test site. This commercial scale reference plant was completed in mid-August 2007. Currently conducting operational start-up activities at the University of Toledo, Ohio. The plant is designed to utilize carbonaceous feedstock from coal to biomass including wood chips, rice straw, ethanol plant DDGS, and municipal and industry waste products (i.e. organic sludge, industry waste, petroleum coke) for synthesis gas production. The plant feed system is designed to handle blended feedstock, including coal mixed in any proportion, with the above mentioned materials.

From the middle of 2007, on the Denver, Colorado site, with a daily processing load of 75-200 tons of input material, the TCG installation met and in many cases exceeded the expectations suggested by our modeling and calculations.

The verification of these and other results was done by independent organizations. "***TSS Consultants"*** (http://www.tssconsultants.com) examined the potential and performance parameters of this thermo-chemical technology from a number of different angles. Five categories (E1-E5) were created and examined:

1. Economic viability (E1)
2. Energy Efficiency (E2)
3. Environmental Compatibility (E3)
4. Research, Development, Demonstration and Deployment (RDD&D) Evaluation Stages (E4)
5. Potential Socio-Political Effectiveness (E5)

These categories were selected and rated using data from several hundred installations worldwide either currently operational or in the planning stages.

After lengthy investigation, the analysts deemed the TCG installation to be the most highly rated, and further recommended it to the United States Senate as one of the foremost methods available today for reducing the importance of fossil fuels in energy generation in a most environmentally-friendly and safe manner.

TSS Consultants concluded that the

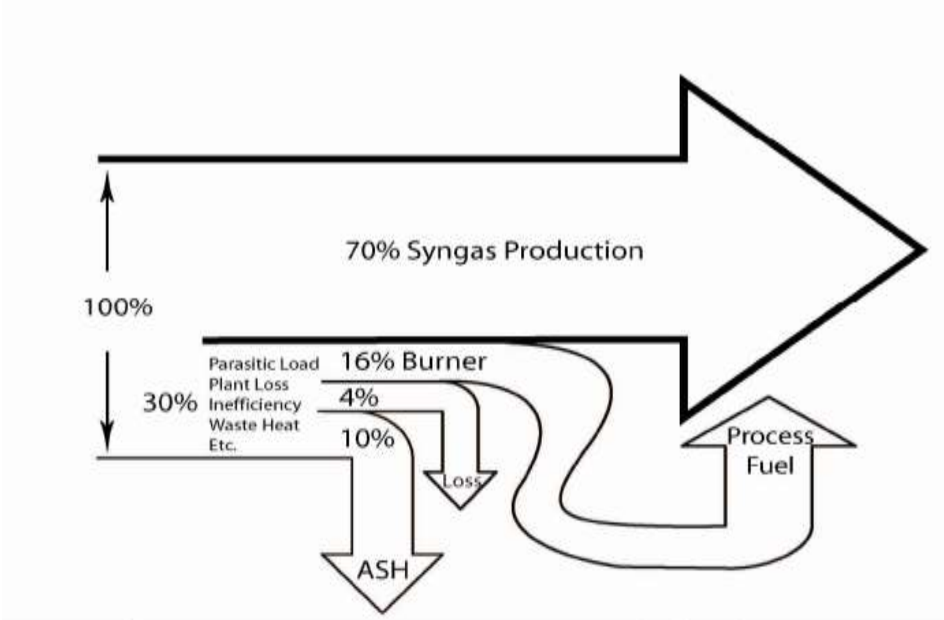
„TC thermo-chemical pyrolysis/steam refining process when conducted in absence of oxygen or air is superior to all other existing technologies examined."

The US House of Representatives, Science and Technology Committee, Subcommittee on Energy and Environment had requested testimony on research and development issues for producing liquid fuels from coal on September 5, 2007. Nationally and internationally recognized environmental scientists and researchers such as Mr. Bartis from RAND Corporation and Dr. Boardman from Idaho National Laboratory testified on the importance of this very issue.

The committee unanimously recommended to the federal government for support research on coal gasification and associated synthesis gas cleaning and treatment processes. These programs are near-term, relatively low risk concepts related mostly for power generation and hydrogen production. That said, many of the programs are also applicable to Fischer-Tropsch (F-T) technology to liquid fuels.

Specific Technology Innovations that are incorporated in the TCG-UC system

- Water Vapor (steam) is added into the system after the water has been super-saturated with negatively charged oxygen using patented water treatment technology (ionized steam reformation)
- Syngas is cooled by quenching with water which is then treated using patented technology to remove all tars and phenols, which are then recycled back into the gasifier. (gas clean-up)
- Partially decomposed particles are recycled through the system to achieve higher reaction efficiency. (carbon re-cycle)
- System operates at lower temperatures, (below vitrification levels) which requires less parasitic load and thus creates higher efficiency (non-slagging gasifier)
- Combustion flu gas can be captured and recycled, with minimal emissions.
- Final ash from system is generally not leachable, or can be contained in cementaciousbyproducts. (non-hazardous)
- Elimination of reactor refractory brick.



Ábra A TCG rendszer energia-folyamatai és részarányuk

Figure 5.2.1.1. Indicative energy flow in the TCG Unit

5.2.2. The input materials of TCG plant

The input/feed material can be **any carbonaceous materials** such as coal, organic waste sewage sludge, animal husbandry waste, agricultural waste like rice hulls, corn stalks, hay, wood, used tires, municipal solid waste, distillery waste, waste from paper milling, low-quality coals, to name a few from an almost limitless field of others.

One of the significant advantages of the TCG plant is that it can be operated with any of the previously mentioned feed materials **or their combination in any ratio**. Although for optimum operation efficiency the moisture content of the feed material is preferred to be below 40%, the plant can operate with feed material of any moisture content **without drying** requirements.

ANY CARBONIFEROUS MATERIALS CAN BE USED IN THE TCG UNIT

5.2.3. The output material (s) /product(s) of a TCG unit.

- **Synthetic gas (Syngas):** It can be utilized directly as fuel into engines or turbine or utilized as chemical feedstock for chemical/catalytic processes.
- **Ash:** The quantity and quality of the produced ash depends upon the mineral content of the input/feed material. The produced ash is generally not water soluble and can be utilized in the construction industry as a cement additive, or it can be utilized in the agriculture as a soil conditioner.

Synthetic gas (Syngas)

One of the significant advantages of the TCG is that it produces very clean syngas with the composition (H_2, CO, CO_2, CH_4), which can be adjusted in a wide range. The syngas can be utilized for:

- heating
- energy production
- through Methanation to produce synthetic natural gas (SNG)
- hydrogen production

as well as feedstock to produce liquid hydrocarbons such as ethanol, methanol or other products.

There are no other liquid or gaseous emissions or environmental pollutants whatsoever formed by the TCG Unit and its processes

5.2.4. Drawings

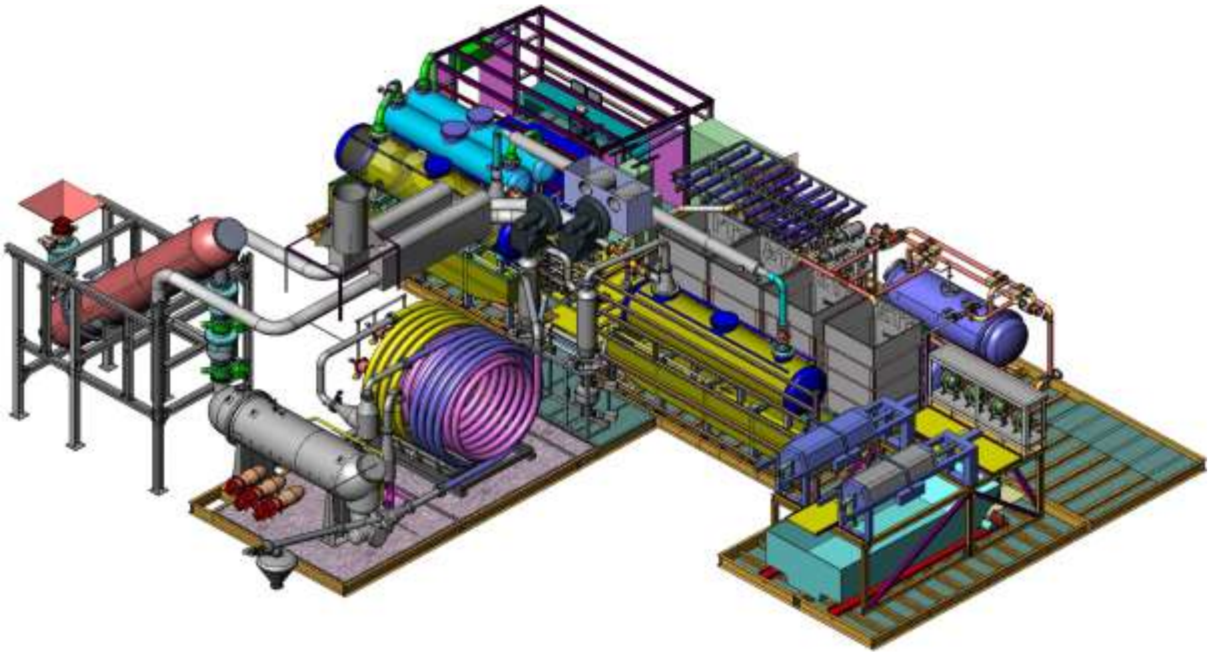


Figure 5.2.4.1. The system of TCG Unit

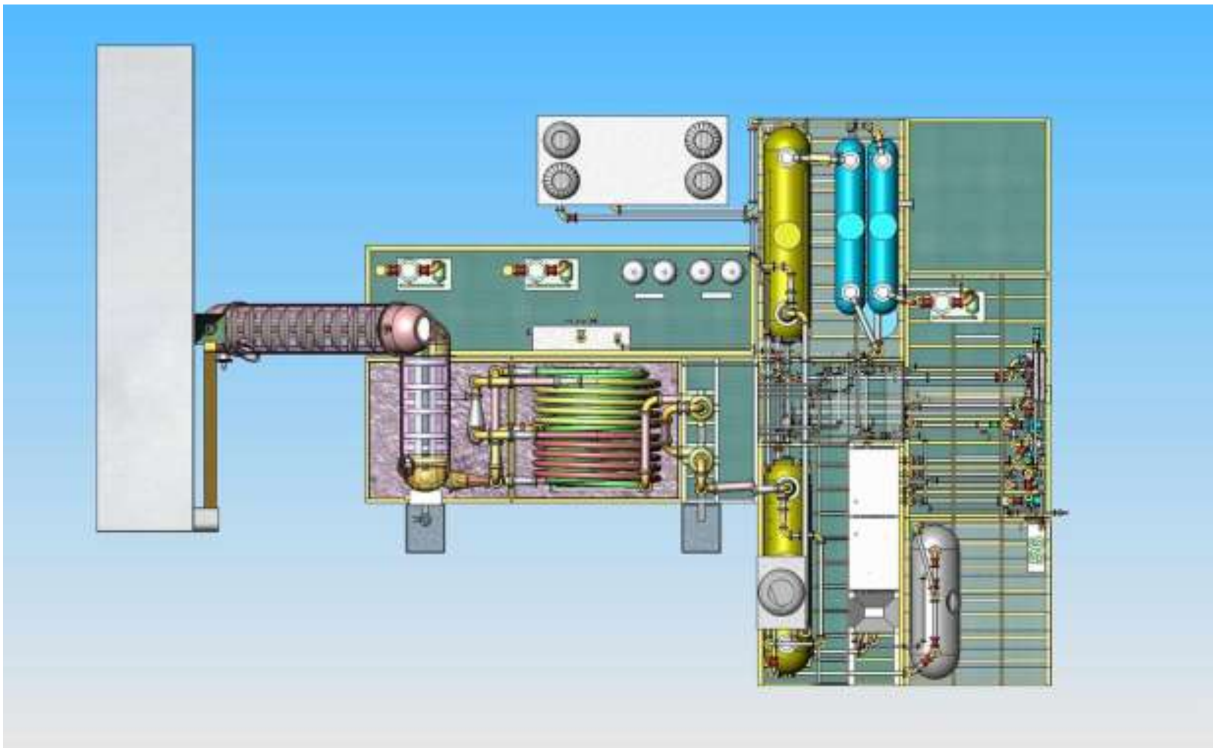


Figure 5.2.4.2. Top view

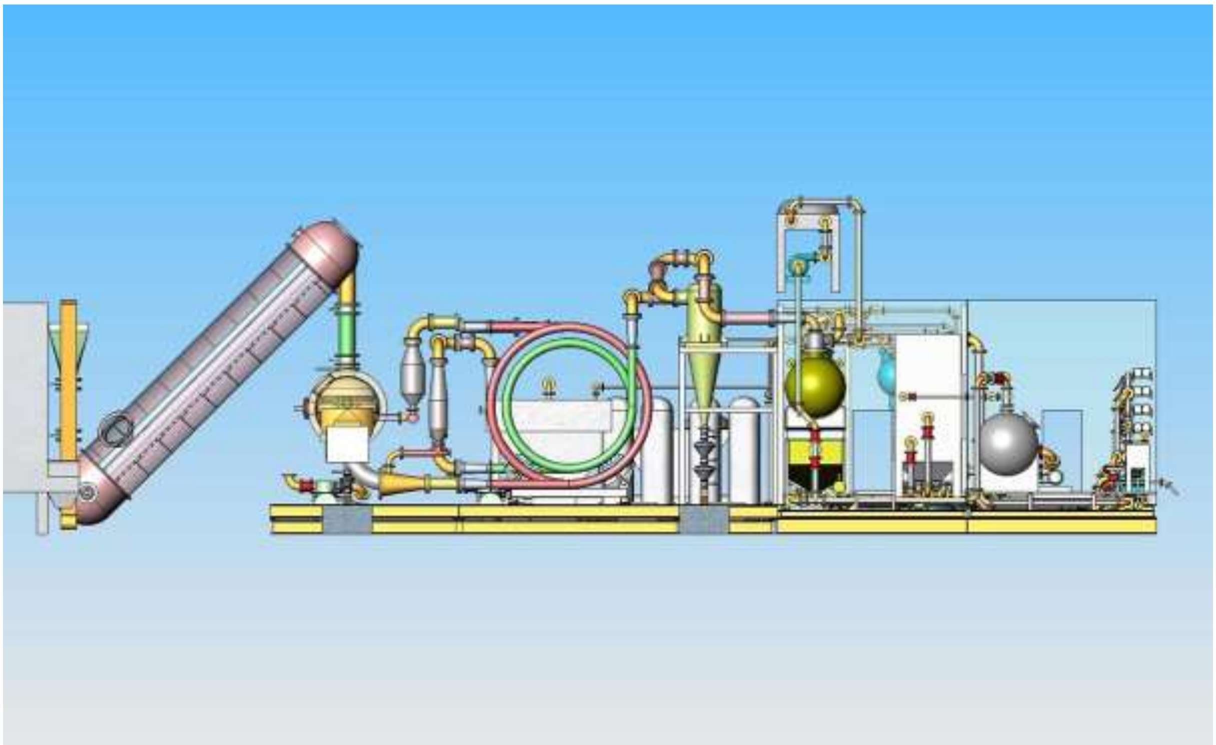


Figure 5.2.4.3. Side view

5.2.5. The operation of the TCG Unit

The raw feed material will go through a separator unit, and thereafter will proceed to a shredder/crusher system (which is a part of the TCG plant) and the prepared feed through a specifically designed feeder will proceed into the pyrolysis chamber. The feed material (depending upon the quality and quantity) will spend an appropriate time under a well-defined pressure and temperature in the chamber. In the pyrolysis chamber, the chemical decomposition of the carbonaceous material begins, into char and other elements, that either will be separated from the material flow at the end of the chamber or as the char proceeds into the gasification reactors/coils

In the gasifying reactor/coils, at elevated temperature and under well controlled conditions, the basic reactions that are well known for gasification professionals takes place. The un-reacted or partially reacted particles are recirculated at a different stage of the reactor, and by doing so the system achieves almost 100% reaction/conversion efficiency of the input carbon. The pressure, temperature and other parameters in the gasification reactor/coils can be changed and adjusted in order to influence the composition of the produced syngas.

The TCG unit contains a patent protected Vapor Ion Plasma,that jointly with other special elements generates a plethora of superoxides in addition to peroxides and hydroxide, all of which are extremely aggressive oxidants, coagulants, sorption agents, reductants and disinfectants. This system is utilized to clean the raw syngas of almost all and any contaminant that was in the feed material, and by doing so producing a very high purity clean syngas.

The primary output of the TCG plant is syngas (which is utilized in subsequent processes or in direct utilization as fuel in gas motors), and the byproduct is ash/slag. The ash/slag from the gasifier will not contain materials in a toxic form; it is vitrified, which will prevent mobility or dissolution in water. The waste product can be easily handled with other non-toxic byproducts or waste material for disposal purposes. However, in each case, it is recommended to carry out special tests on the ash or slag to assure that the handling system of the byproduct will meet Hungarian regulations, especially in the case that it is to be utilized as a road base material or in similar construction works.

5.2.6. References

(Ref. **A Technical, Economic, Energy and Environmental Assessment of Thermochemical Systems for Conversion of Sewage Sludge and Other Waste Biomass Materials performed by TSS Consultants,USA)**

„TSS Consultants (TSS) carried out a technical assessment on the potential application of various thermochemical processes for the conversion of waste biomass at the East Bay Municipal Utility District (EBMUD) wastewater treatment plant in Oakland, California. The principle authors of this study have spent several years compiling a database of more than 400 organizations that have developed technologies for thermally converting biomass into energy, fuels and/or chemicals. The technologies developed by these 400 organizations are divided into nine categories. Seven of these nine categories utilize thermochemical processes and two employ thermo-biological processes. The thermo- biological processes were not considered for this study.

A promising candidate technology was chosen from each of the seven categories. Each of these candidate technologies was evaluated for the potential conversion of low, medium and high projections of biomass conversion at EBMUD. The comparative evaluation included assessments of each system's Economic viability (E1), Energy efficiency (E2), Environmental compatibility (E3), progress in each of the Research, Development, Demonstration and Deployment (RDD&D) Evaluation stages (E4), and its potential socio-political Effectiveness (E5).

Table 1 summarizes the results of this analysis. The numbers in *Italics* gives the ratings for E1-E5 and E6 is the total ranking. As based upon this analysis, Thermal Pyrolysis/Steam Reforming (no oxygen) (rating: 50) was chosen as a potentially viable technology for this application. The next two technologies, Integrated Thermal Gasification/Oxidation (rating: 49) and Thermochemical Gasification (no oxygen) (rating: 42) may also be suitable for this application. The Integrated Thermal Gasification/Oxidation system may be preferred if it is decided that heat is a more important energy product than electricity.

On the basis of the E5 analysis, the Thermal Pyrolysis/Gasification/Steam Reforming technology was chosen as the most promising technology and BCT/ACT (Denver, CO) is a capable, candidate supplier of this technology. Therefore, the BCT/ACT technology was selected as the candidate technology for the preliminary design/engineering of a full- scale production plant, the cost analysis and an evaluation of the probability of success."

Biomass to Energy Technologies [1]	(E1) Economic Analyses (Electricity Cost ($/KWH) & Amortized Cost) [2]	(E2) Energy Analyses (Electricity (KWH/yr & Heat (MT/yr))	(E3) Environmental Assessment	(E4) Evaluation (RDD&D[3] Validation)	(E5) Effectiveness	(E6) Total Rating
Thermal Pyrolysis/Steam Reforming (No Oxygen)	$0.048/KWH $4.07 M/yr *(17)*	6.64 x 10^{+7} KWH/yr & 1.0 MT/yr) *(9)*	*(8)*	*(8)*	*(8)*	*(50)*
Integrated Thermal Gasification/ Oxidation	$0.054/KWH $3.38 M/yr *(15)*	3.76 x 10^{+7} KWH/yr & 2.0 MT/yr *(7)*	*(7)*	*(13)*	*(7)*	*(49)*
Thermochemical Gasification (No Oxygen	$0.067/KWH $5.05 M/yr *(12)*	6.20 x 10^{+7} KWH/yr & 1.0 MT/yr *(8)*	*(8)*	*(6)*	*(8)*	*(42)*
Thermochemical Gasification (With Oxygen)	$0.079/KWH $5.17 M/yr *(8)*	5.53 x 10^{+7} KWH/yr & 0.90 MT/yr *(7)*	*(6)*	*(14)*	*(6)*	*(41)*
Thermal Pyrolysis (No Oxygen)	*Not Applicable*	*Not Applicable*	*(5)*	*(6)*	*(5)*	*Not Applicable*
Thermal Oxidation (Combustion)	$0.174/KWH $5.82 M/yr *(3)*	2.57 x 10^{+7} KWH/yr & 1.5 MT/yr *(5)*	*(2)*	*(18)*	*(2)*	*(30)*

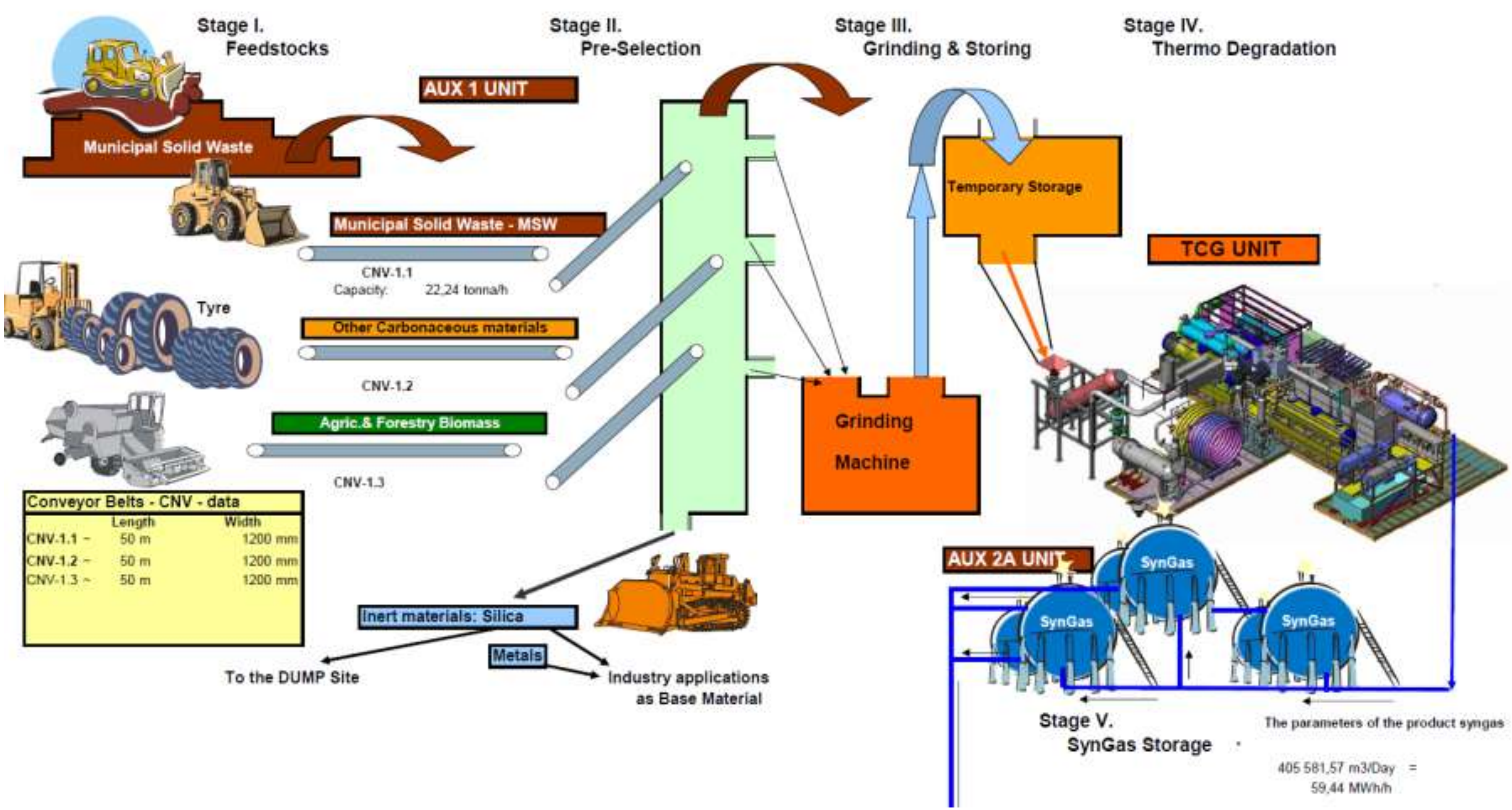
[1] Numbers in *Italics* represent ratings for E1-E5 – See Section 3.2 for details on rating system criteria
[2] Total Costs = Straight-line deprecation of capital costs (20 years depreciation of capital expenditures) plus annual operating and maintenance costs. The electricity cost calculation assumes that the EBMUD facility
will be able to utilize up to 2.0 million Therms of heat energy each year
[3] RDD&D: Research, Development, Demonstration and Deployment Assessment Stages.

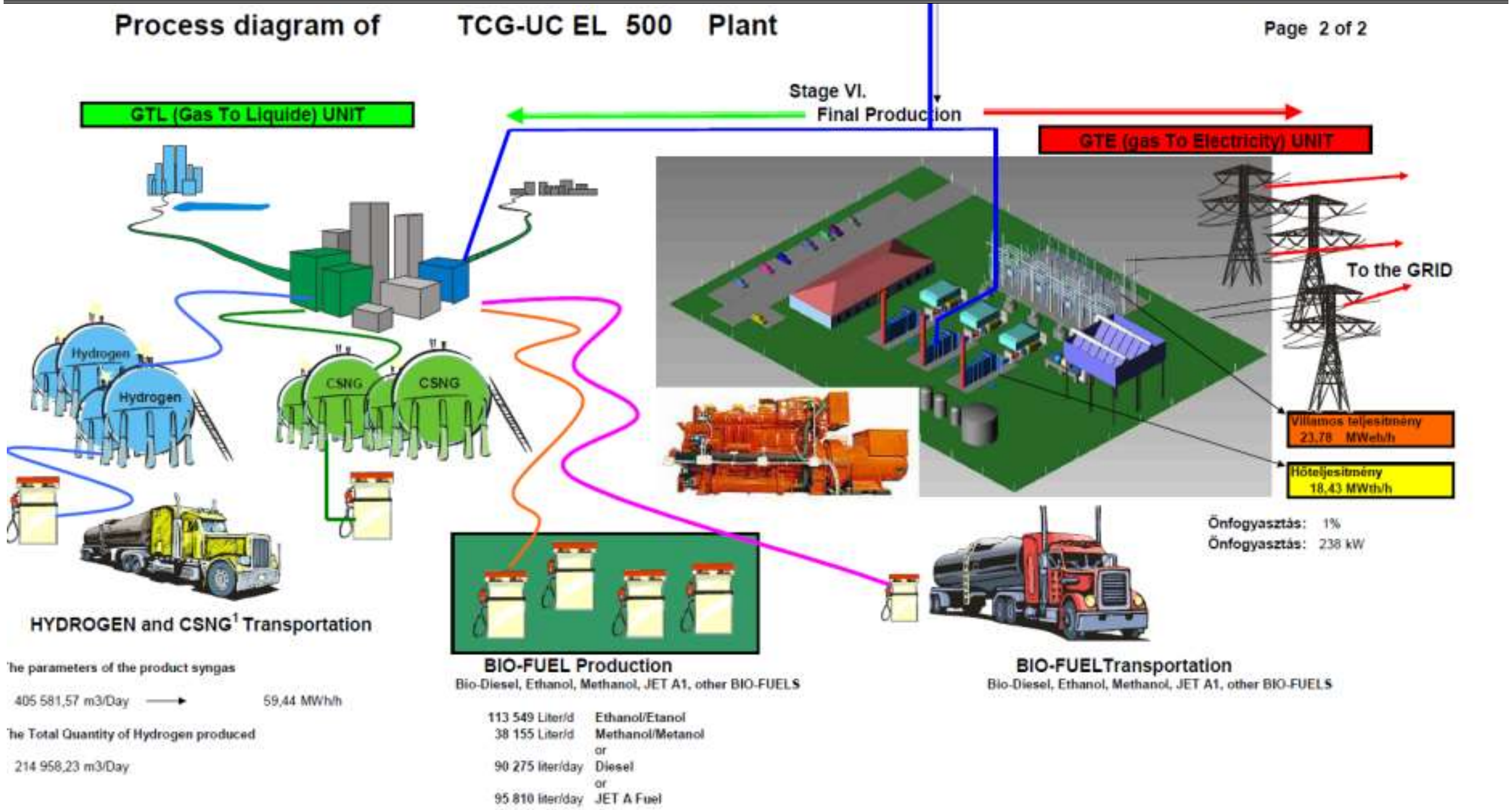
Table 5.2.6.1. The ranking list and the points of the technologies investigated

As it can be seen in the table the „**Thermal Pyrolysis/Steam Reforming (No Oxygen)" -** that is the TCG technology - was ranked to the first place in the World.

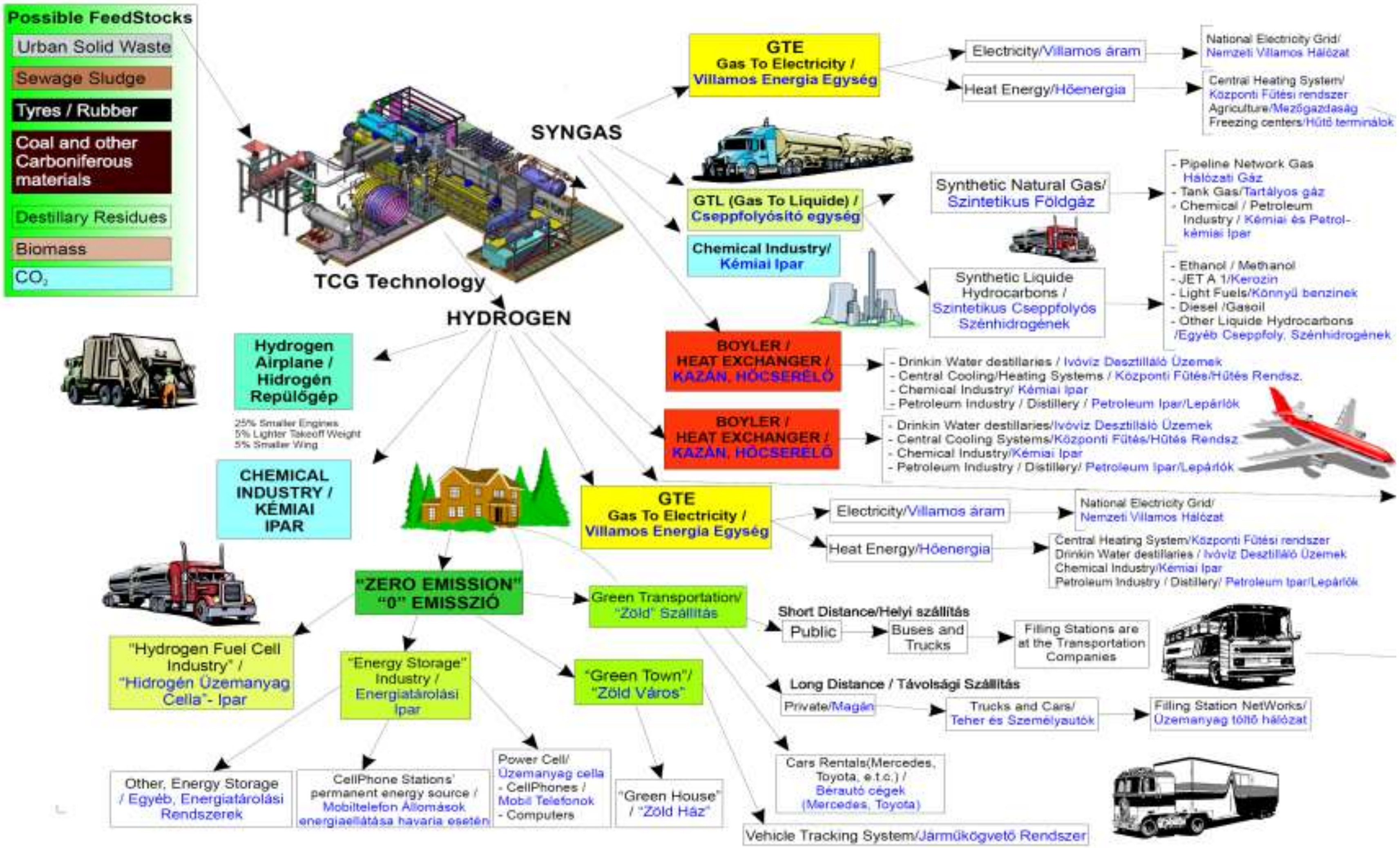
Process diagram of TCG-UC EL 500 Plant

Page 1 of 2





Process diagram of TCG-UC EL 500 Plant
Page 2 of 2
Stage VI.
Final Production
GTL (Gas To Liquide) UNIT
GTE (gas To Electricity) UNIT
To the GRID
Hydrogen
Hydrogen
CSNG
CSNG
Villamos teljesítmény 23,78 MWeh/h
Hőteljesítmény 18,43 MWth/h
Önfogyasztás: 1%
Önfogyasztás: 238 kW
HYDROGEN and CSNG[1] Transportation
he parameters of the product syngas
405 581,57 m3/Day
59,44 MWh/h
he Total Quantity of Hydrogen produced
214 958,23 m3/Day
BIO-FUEL Production
Bio-Diesel, Ethanol, Methanol, JET A1, other BIO-FUELS
113 549 Liter/d Ethanol/Etanol
38 155 Liter/d Methanol/Metanol
or
90 275 liter/day Diesel
or
95 810 liter/day JET A Fuel
BIO-FUELTransportation
Bio-Diesel, Ethanol, Methanol, JET A1, other BIO-FUELS


Possible FeedStocks
Urban Solid Waste
Sewage Sludge
Tyres / Rubber
Coal and other Carboniferous materials
Destillary Residues
Biomass
CO_2
TCG Technology
SYNGAS
HYDROGEN
GTE
Gas To Electricity / Villamos Energia Egység
Electricity/Villamos áram
National Electricity Grid/ Nemzeti Villamos Hálózat
Heat Energy/Hőenergia
Central Heating System/ Központi Fűtési rendszer
Agriculture/Mezőgazdaság
Freezing centers/Hűtő terminálok
GTL (Gas To Liquide) / Cseppfolyósító egység
Synthetic Natural Gas/ Szintetikus Földgáz
- Pipeline Network Gas Hálózati Gáz
- Tank Gas/Tartályos gáz
- Chemical / Petroleum Industry / Kémiai és Petrol-kémiai Ipar
Chemical Industry/ Kémiai Ipar
Synthetic Liquide Hydrocarbons / Szintetikus Cseppfolyós Szénhidrogének
- Ethanol / Methanol
- JET A 1/Kerozin
- Light Fuels/Könnyű benzinek
- Diesel /Gasoil
- Other Liquide Hydrocarbons /Egyéb Cseppfoly. Szénhidrogének
BOYLER / HEAT EXCHANGER / KAZÁN, HŐCSERÉLŐ
- Drinkin Water destillaries / Ivóviz Desztilláló Üzemek
- Central Cooling/Heating Systems / Központi Fűtés/Hűtés Rendsz.
- Chemical Industry/ Kémiai Ipar
- Petroleum Industry / Distillery / Petroleum Ipar/Lepárlók
BOYLER / HEAT EXCHANGER / KAZÁN, HŐCSERÉLŐ
- Drinkin Water destillaries/Ivóviz Desztilláló Üzemek
- Central Cooling Systems/Központi Fűtés/Hűtés Rendsz
- Chemical Industry/Kémiai Ipar
- Petroleum Industry / Distillery/ Petroleum Ipar/Lepárlók
Hydrogen Airplane / Hidrogén Repülőgép
25% Smaller Engines
5% Lighter Takeoff Weight
5% Smaller Wing
CHEMICAL INDUSTRY / KÉMIAI IPAR
GTE
Gas To Electricity / Villamos Energia Egység
Electricity/Villamos áram
National Electricity Grid/ Nemzeti Villamos Hálózat
Heat Energy/Hőenergia
Central Heating System/Központi Fűtési rendszer
Drinkin Water destillaries / Ivóviz Desztilláló Üzemek
Chemical Industry/Kémiai Ipar
Petroleum Industry / Distillery/ Petroleum Ipar/Lepárlók
"ZERO EMISSION" "0" EMISSZIÓ
Green Transportation/ "Zöld" Szállítás
Short Distance/Helyi szállítás
Public
Buses and Trucks
Filling Stations are at the Transportation Companies
Long Distance / Távolsági Szállítás
Private/Magán
Trucks and Cars/ Teher és Személyautók
Filing Station NetWorks/ Üzemanyag töltő hálózat
Cars Rentals(Mercedes, Toyota, e.t.c.) / Bérautó cégek (Mercedes, Toyota)
Vehicle Tracking System/Járműkögvető Rendszer
"Hydrogen Fuel Cell Industry" / "Hidrogén Üzemanyag Cella"- Ipar
"Energy Storage" Industry / Energiatárolási Ipar
"Green Town"/ "Zöld Város"
Other, Energy Storage / Egyéb, Energiatárolási Rendszerek
CellPhone Stations' permanent energy source / Mobiltelefon Állomások energiaellátása havaria esetén
Power Cell/ Üzemanyag cella
- CellPhones / Mobil Telefonok
- Computers
"Green House" / "Zöld Ház"

5.3. The GTE PLANT

5.3.1. GTE (Gas To Electricity) Unit - Producing electric and heat energy.

5.3.1.1. Electric energy production

Major improvements in gas motor and turbine technology make it possible to utilize the syngas directly in both gas motor and gas turbine and generator sets. A TCG unit utilizing app 500 TPD input material can produce large quantities of electric energy (**20-28 MW_eh/h**) with high efficiency, all the while utilizing sustainable resources. Careful modeling and design is required to match the capacity of the TCG unit with the operation parameters of the gas motor generator or turbine set in order to assure efficient and reliable operation without de-rating any units.

5.3.1.2. Heat energy

The quantity of discharged heat during the operation of a gas-turbine or gas-motor is very significant; consequently the system is designed such a way that the maximum of the emitted heat (waste heat) is recovered and utilized. The quantity of the recovered heat energy can be as large as (**10-19 MW_{th}h/h).**

5.3.3. GTL (Gas To Liquid) Unit – Manufacturing liquid hydrocarbon

(GTL Unit is not part of the TCG-UC EL1500TH-TPY project, but it can be installed there in a later stage, if needed)

Chemicals or fuels (methanol, ethanol, diesel, JET A1 Fuel) have been manufactured based on the well-known Fischer-Tropsh technologies for many years. The economics of these technologies depends upon many technical parameters and the quality of the catalysts used, but until now, one thing has always been a common requirement: the quality (cleanness) of the input material.

The TCG is able to produce high quality clean output/syngas that is an excellent feedstock material for the Fischer-Tropsh process with very little if any special cleaning. This increases the feasibility of applying the TCG technology significantly.

Further, the advantages of the TCG unit is that the feed material can be a mix of coal and bio-mass that can make possible utilizing previously unusable coal reserves that, mixed with bio-mass, may help to increase the quantity and quality of the produced syngas. It is possible to produce syngas whose contents have a **H_2 to CO ratio as high as 3:1.** The hydrogen to carbon-monoxide ratio is a very important parameter in determining the effectiveness of the production of liquid hydrocarbon. A ratio of between 2 and 3 is the ideal to convert syngas into liquid hydrocarbon.

Recognizing this very important feature of the TCG unit, the US Department of Energy selected the facility to produce the syngas for a major research program, manufacturing bio-diesel utilizing the syngas.

As mentioned earlier, the composition of the produced syngas can be well-controlled and set to any required composition within a reasonable rage. This can be extremely important if the purchaser/owner intends to produce hydrogen. The hydrogen content in the TCG-produced syngas can be set as high as 80% or higher, which makes the TCG an excellent solution for hydrogen production on a commercial scale.

5.3.3. SNG (Synthetic Natural Gas) Unit

(SNG Unit is not part of the TCG-UC EL1500TH-TPY project, but it can be installed there in a later stage, if needed)

Methanation for manufacturing synthetic natural gas

The catalytic methanation reaction converts the syngas produced by the TCG plant into methane, and finely applying an efficient process to produce synthetic natural gas (SNG) of which a major component is methane. In the exothermic methanation reaction lower temperature and/or higher pressure were favorable to increase CO conversion to methane. However, there are limitations to the methanation reaction using the syngas with high CO conversion. These can be overcome by adding H_2 to the feed syngas. The TCG produced syngas can contain the optimum H_2 content that helps to overcome the thermodynamic limitations, enhance the CO conversion to methane, and result in an efficient SNG production system.

It is worthy to note that the produced SNG can be utilized with 60% less emissions than the natural gas.

5.3.4. Hydrogen Unit

Since the hydrogen content of the TCG produced syngas can be 15 – 90%, the plant provides a very easy solution for establishing a commercial-scale hydrogen production systems. The rapid development of reliable and economical hydrogen-fuel cells make it inevitable that large portion of the transportation industry can be changed to hydrogen fuel based that is not only less expensive but extremely environmentally friendly, especially for mass transportation systems.

5.4. AUXS

The keystone of the auxiliary unit is the feed material handling, pre-sorting and processing unit (AUXS1). The reliable operation and functioning of this system is of the utmost importance because it assures the continuous and optimal operation and production of the TCG unit. Other vital parts of this unit are those equipments and facilities that provide the power and water to the plant, and those that assure the smooth and effective uploading of the produced electric and heat energy to the appropriate local or national grids/pipelines (AUXS2).

5.4.1. AUXS1

(Pre-selection, sorting, shredding and crunching, handling equipment of input material, and transportation equipments)

Municipal solid waste requires careful sorting, and that is best done at the waste disposal site. During the sorting process, metals, rocks, glasses and other silicate material are selected from the waste. The sorted organic waste material is then shredded or ground to the required size that (directly or after further processing) can be fed into the TCG unit.

In case the TCG unit is located away from the feed material sorting and processing site, the feed should be transported in pressure-containers or by conveyor belt to the TCG site depending ont he circumstances and requirements. For logistics and safe operations reason, at the TCG site feed storage (generally in bunkers or large storage tanks) with appropriate capacity should be established. Transporting the feed material from the storage tanks or bunkers will be resolved by special conveyor, and other material handling equipment.

5.4.2. AUXS 2

(End product (s) handling and transportation system, tanks, water and waste water storage and disposal, power substation and, power connecting point etc.)

This sub-system consists of all the other material handling and transportation equipment, the power and water supply, and the product transportation system to the transfer point. These are very much product and site specific issues and require careful design.

5.5. Industrial Security and Healthcare systems

The risk management is a very important issu of the manufacturing.

5.5.1. Fire prevention, fire protection

5.5.2. Health Care and Service

5.6. Tests, practical experience and suggestion

The TCG unit (one of the major elements of the power system) will be assembled at the manufacturer's or at the supplier's site where it will be fully tested by the manufacturer, and a certification will be provided to the purchaser concerning the performance parameters. Third party expert(s) and the representative of the purchaser will participate in the testing process.

Further testing will be carried out at the purchaser's site where the TCG will be assembled and, during the first two weeks after assembly, will be used to train the operators.

Similarly, the other units such as GTE or Methanation will be tested once by the manufacturer and again at the site after the complete system has been assembled.

The supplier is committed to hand over to the purchaser a fully tested and fully operational unit with all the documentation and operation manuals in a timely fashion.

Some sample testing minutes issued by the manufacturer, about the test running of the TCG unit at the test facility in Colorado State, USA.

Report on TCG testing at steady-stage

Place: Denver testing facility
Corroborant:

Feedstock data, Average Performance parameters provided by the Manufacturer

Information concerning the test on the Manufacturer's site

	Test Running at Steady Stage	MSW HW5915/15MC-A20		8.12.2007	
I	**Parameters of the Feed material**				
1	Quantity on dry basys	237,00	TPD		
2	Quantity total	278,82	TPD		
3	Energy content (BTU/lbs as received)	5 915	BTU/lb		
4	Energy content (BTU/lbs reduced for dry)	6 959	BTU/lb		
II	**Parameters of the process**				
1	Carbon mass balance				
1.a	Total feedstock input	23 235,31	lbs/hr	10 539,42	kg/hr
1.b	Total Carbon input	15 102,95	lbs/hr	6 850,62	kg/hr
	1.b.1. Fixed Carbon content in the feed	50,00	% on dry basis		
	1.b.2. Fixed carbon by weight	11 617,66	lbs/hr	5 269,71	kg/hr
1.c	Carbon left in ash	by test	lbs		kg
1.d	Total carbon converted	by test	lbs		kg
1.e	Carbon conversion	by test	%		
2	Sulfur mass balance				
2.a	Total sulfur in feed	278,82	lbs/hr	126,47	kg/hr
2.b	Sulfur in filter cake		lbs/hr		kg/hr
3	Energy balance				
3.a	Input from feed	3 298,49	mmBTU/d	3 477,76	GJ/day
3.b	Output as syngas	2 450,77	mmBTU/d	2 583,97	GJ/day
3.c	Efficiency of the TCG Plant	74,30	%		

Figure 5.5.1. The test minutes of MSW testing

Report on TCG testing at steady-stage

Place: Denver testing facility
Corroborant:

Feedstock data, Average Performance parameters provided by the Manufacturer					
Information concerning the test on the Manufacturer's site					
	Test Running at Steady Stage	**MSW HW4895/15MC-A20**		**10.12.2007**	
I	**Parameters of the Feed material**				
1	Quantity on dry basys	227,00	TPD		
2	Quantity total	267,06	TPD		
3	Energy content (BTU/lbs as received)	4 895	BTU/lb		
4	Energy content (BTU/lbs reduced for dry)	5 759	BTU/lb		
II	**Parameters of the process**				
1	Carbon mass balance				
1.a	Total feedstock input	22 254,92	lbs/hr	10 094,72	kg/hr
1.b	Total Carbon input	14 465,70	lbs/hr	6 561,57	kg/hr
	1.b.1. Fixed Carbon content in the feed	50,00	% on dry basis		
	1.b.2. Fixed carbon by weight	11 127,46	lbs/hr	5 047,36	kg/hr
1.c	Carbon left in ash	by test	lbs		kg
1.d	Total carbon converted	by test	lbs		kg
1.e	Carbon conversion	by test	%		
2	Sulfur mass balance				
2.a	Total sulfur in feed	267,06	lbs/hr	121,14	kg/hr
2.b	Sulfur in filter cake		lbs/hr		kg/hr
3	Energy balance				
3.a	Input from feed	2 614,51	mmBTU/d	2 756,61	GJ/day
3.b	Output as syngas	2 010,56	mmBTU/d	2 119,83	GJ/day
3.c	Efficiency of the TCG Plant	76,90	%		

Figure 5.5.2. The test minutes of MSW testing

SYNERGY ENERGETICS T.L. Corp.

Report on TCG testing at steady-stage

Place: Denver testing facility
Corroborant:

Feedstock data, Average Performance parameters provided by the Manufacturer
Information concerning the test on the Manufacturer's site

Test Running at Steady Stage MSW HW5468/16MC-A20 14.12.2007

I	**Parameters of the Feed material**				
1	Quantity on dry basys	239,00	TPD		
2	Quantity total	284,52	TPD		
3	Energy content (BTU/lbs as received)	5 468	BTU/lb		
4	Energy content (BTU/lbs reduced for dry)	6 510	BTU/lb		
II	**Parameters of the process**				
1	Carbon mass balance				
1.a	Total feedstock input	23 710,34	lbs/hr	10 754,89	kg/hr
1.b	Total Carbon input	15 411,72	lbs/hr	6 990,68	kg/hr
	1.b.1. Fixed Carbon content in the feed	50,00	% on dry basis		
	1.b.2. Fixed carbon by weight	11 855,17	lbs/hr	5 377,45	kg/hr
1.c	Carbon left in ash	by test	lbs		kg
1.d	Total carbon converted	by test	lbs		kg
1.e	Carbon conversion	by test	%		
2	Sulfur mass balance				
2.a	Total sulfur in feed	284,52	lbs/hr	129,06	kg/hr
2.b	Sulfur in filter cake		lbs/hr		kg/hr
3	Energy balance				
3.a	Input from feed	3 111,56	mmBTU/d	3 280,67	GJ/day
3.b	Output as syngas	2 408,34	mmBTU/d	2 539,24	GJ/day
3.c	Efficiency of the TCG Plant	77,40	%		

Figure 5.5.3. The test minutes of MSW testing

5.7. Permitting

The TCG operation permitting will be carried out as specified in this proposal.

The company has been engaged in close consultation and discussion with the Ministry of National Economy, the Ministry of Provincial Development and the Ministry of National Development to develop and introduce an efficient and expeditious permitting process in compliance with the prevailing laws and regulations. It is expected that the usual duration of the permitting process will be significantly reduced.

The Project's *Realization Plan* contains the milestones and time durations for specific events, although a similar realization plan is also made only for the permitting process.

Although the company has every reason to believe that the permitting process will be expeditious, it is strongly suggested that (as the project is not a governmental priority program) the purchaser should initiate the permitting process at the earliest possible time. It is of paramount importance that the purchaser should have the operation permit by the planned date of when the TCG system is due to be shipped to the purchaser's site.

5.8. Security

Both the Northern and the Southern part of the site will be fenced with a minimum of 200 cm wire-lattice, with a cca 50 cm diameter barbed wire loop on the top. Both the Northern and the Southern site there are control and territorial guard places, where the guards have been on duty. The sites are controlled and secured by both electronic and manpower as well. The fences are observed by digital video cameras and the camera views are archived.

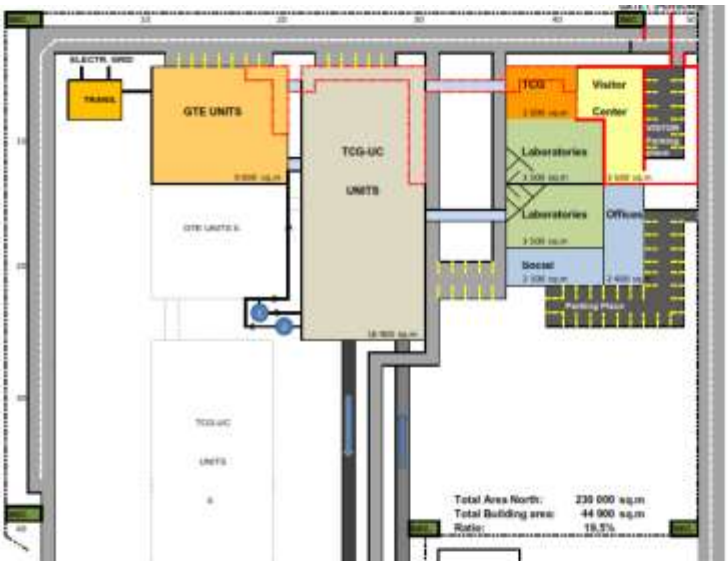


Fig. 5.8.1. The sample of security fence

Fig. 5.8.2. The security guards posts I.

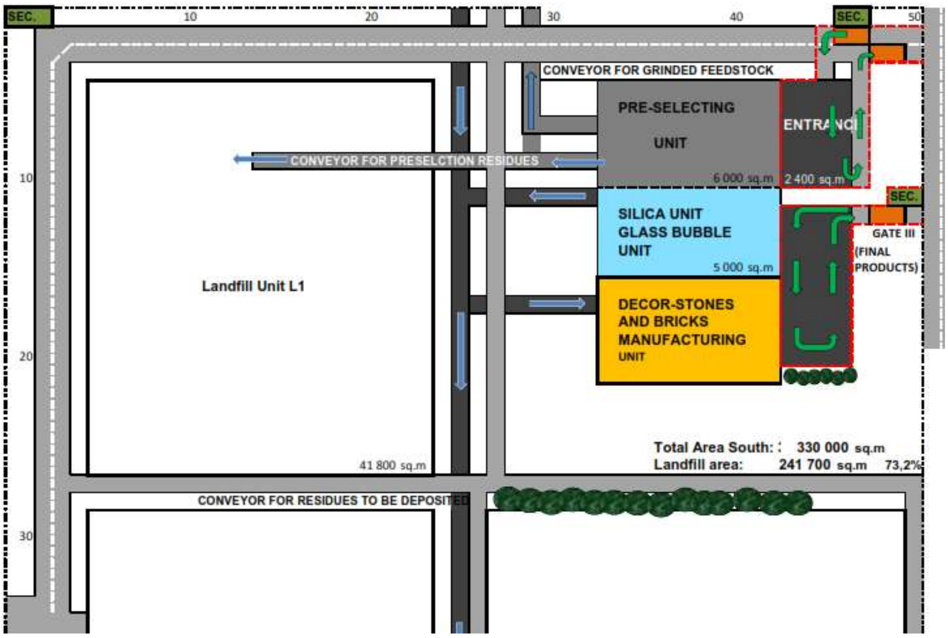


Fig. 5.8.3. The security guards posts II

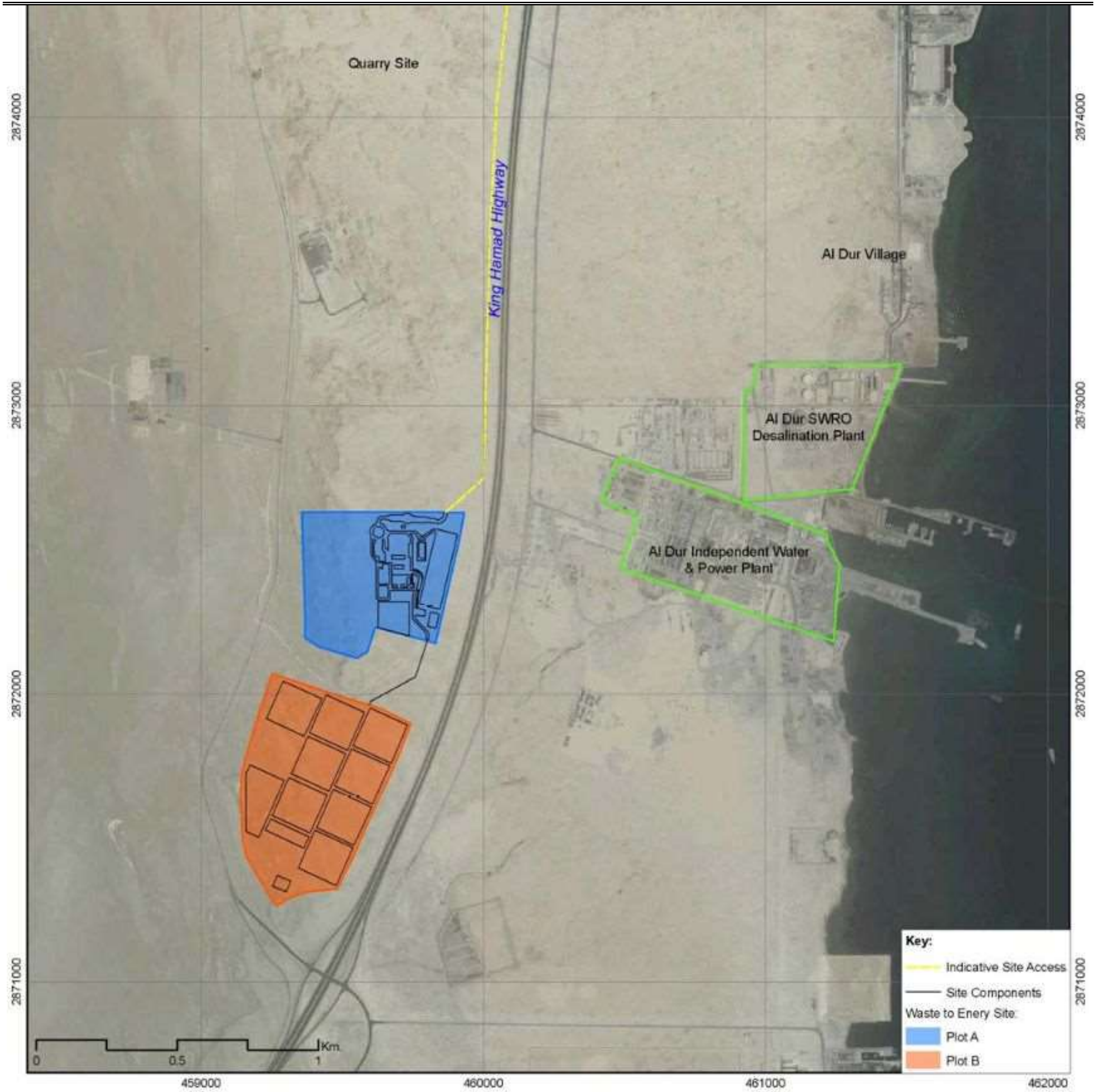


Figure 5.8.4. The TCG Power plant and the Landfill plots

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VI. THE SUMMARY OF THE PROJECT

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6. Summary

6.1. The financial overview of the project.

The projects' economy can be seen through the model calculation.

- The location of a TCG plant is: Askar Municipal Landfill Site / Kingdom of Bahrain
- The imput/feed material of the TCG-UC PP must be pre-sorted in the Askar Municipal Landfill Site (altogether 3 086 tons per day as received basis).

The pre-sorted waste material is carried by conveyor system to the TCG UNIT. The end products of the TCG power plant are electricity and heat-energy. The produced electrical energy can be directly fed into the national electric grid, and the heat-energy can be utilized in different technical and agricultural production.

Basic financial data of the investment/project:

Number of unit =1	**1 Unit**
Total input material (on as received basis) (TPD)	514,00
Total input energy (MJ/d)	6 235 135
Salable produced electric energy ($MW_e h/h$)	20.21
Salable heat energy ($MW_{th} h/h$)	15.66
Salable heat power (GJ/h)	56,38
Total investment requiremen t (BHD)	68 951 986,-
Labor cost (BHD/year)	3 239 010,-
Yearly operation cost (BHD/year)	9 958 435,-
Total income/revenue (BHD/year)	19 742 348,-
EBITDA (BHD/year)	6 544 903,-

Table 6.1.1.

Number of units=6	**6 Units**
Total input material (on as received basis) (TPD)	3 086,00
Total input energy (MJ/d)	37 411 526
Salable produced electric energy ($MW_e h/h$)	121,26
Salable heat energy ($MW_{th} h/h$)	93,96
Salable heat power (GJ/h)	338,26
Total investment requirement (BHD)	410 525 194,-
Labor cost (BHD/year)	16 673 159,-
Yearly operation cost (BHD/year)	61 092 000,-

Total income/revenue (BHD/year)	118 501 655,-
EBITDA (BHD/year)	40 736 496,-
Rate of return (%)	7
Time of return of investment (year)	10,08

Table 6.1.2.

6.2. Technological and financial computer modeling

Input material: 962 964 ton of sorted municipal solid waste per year for 6 units

6.2.1. General issues

6.2.1.1. Supplier

The purchaser/project company is the SYNERGY & ITH JV.

6.2.1.2. Documentation

The supplier will provide all the documentation (i.e. operation license, operation manual, list of major parts and maintenance schedule, etc.) required to operate the plant/system.

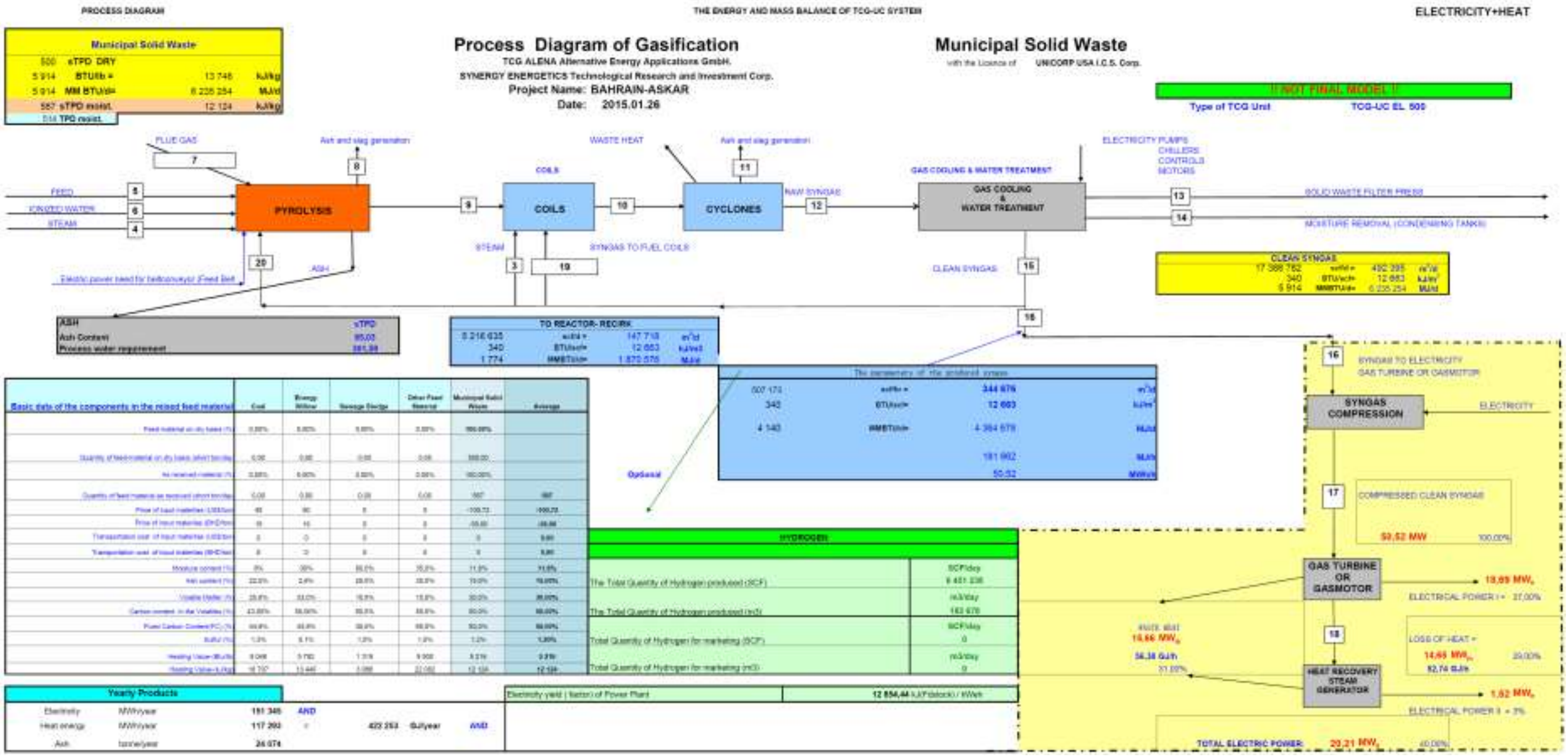
6.2.1.3. Required from the purchaser/project firm

Due to the Joint Venture agreement signed by the parties, the First United Project Development Consultancy Llc. (FUPDC) is responsible providing for the delivery/establishment of TCG-UC EL1500TH-TPY system the appropriate site with the necessary utilities and ownership information as well the information on the availability of the input/feed material and its qualitative and quantitative information/data. Securing the operation permit is also the responsibility of the FUPDC firm, but the supplier will provide full support in the permitting process.

We are ready to submit a detailed EIA Report based on the EA-2 Form for the project and other allied facilities. We concider and accept that the EA-2 form and EIA Report has to be approved by the Environmental Affairs (EA) and other concerned authorities in the Kingdom of Bahrain, prior to undertaking any construction work.
(Ref. „Tender documentation" section 4.25.)

6.3. The technological and financial models of the power plant

6.3.1. The Material Flow Sheet, and the Financial Model of the TCG-UC EL500 Unit



PROFORMA ELECTRICITY

THE PROFORMA OF TCG-UC SYSTEM

ELECTRICITY+HEAT

Preliminary ProForma 567 Short ton per Day using the TCG gasification plant and the TCG-UC System

BAHRAIN-ASKAR Gasification Project

Feeding material: Municipal Solid Waste

Final Product: ELECTRICITY+HEAT

UNICORP USA International Consulting and Servicing Corp.
TCG ALENA Alternative Energy Applications GmbH.
SYNERGY ENERGETICS Technological Research and Investment Corp.

Type of TCG Unit 500

Feedstock Material Municipal Solid Waste
Final Product: ELECTRICITY+HEAT

INPUT MATERIALS		
[illegible]	[illegible]	[illegible]

Date: 2015.01.28

Capital Expenditures	
Item	Cost (BHD)
[illegible]	[illegible]
Total Project (Entire Project)	[illegible] BHD
Daily cost	[illegible] BHD

Payment schedule		
Installment(%)	Sum (BHD)	Proposed period of payment
[illegible]	[illegible]	[illegible]

Annual Operating Costs		
[illegible]	[illegible]	[illegible]

Syngas Production for Sale	
[illegible]	[illegible]

Annual EBITDA	
[illegible]	[illegible]

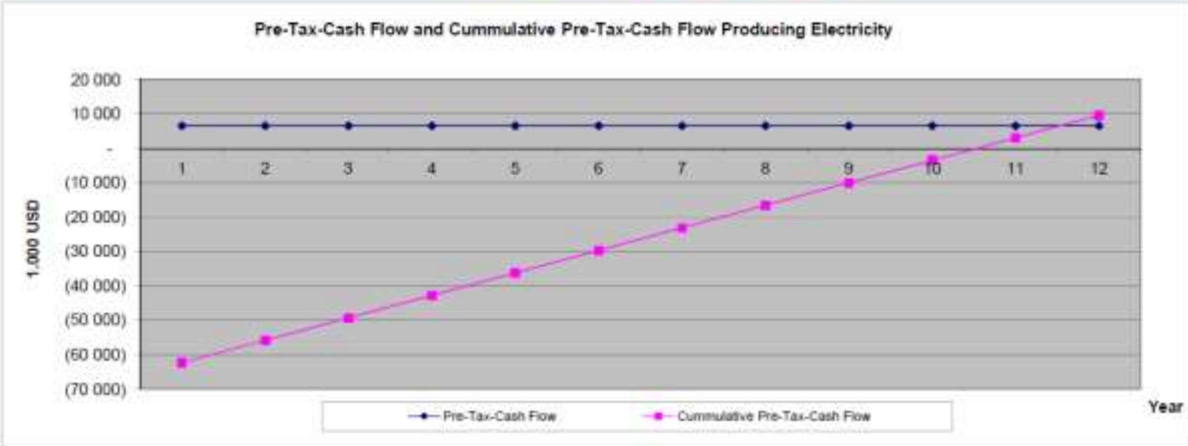
Capital			
Rates of Exchange	HUF	USD	EUR	BHD
[illegible]	[illegible]	[illegible]	[illegible]

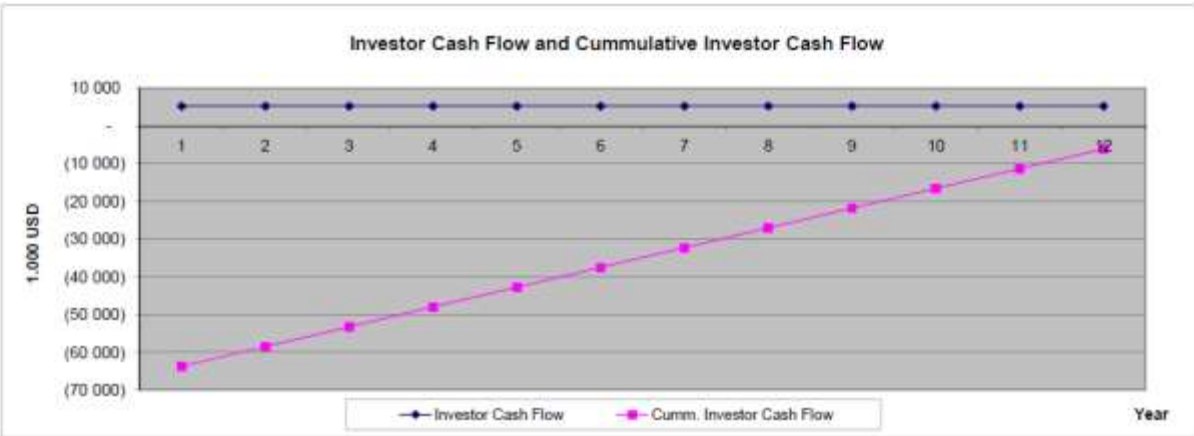
Salary and Labor costs	
[illegible]	[illegible]

Daily Cost	
[illegible]	[illegible]
Daily Income	
[illegible]	[illegible]

Yearly Pro Forma (BHD000)	Year 0 Construction	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10	Year 11	Year 12	Year 13	Year 14	Year 15	Year 16	Year 17	Year 18	Year 19	Year 20	Total
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

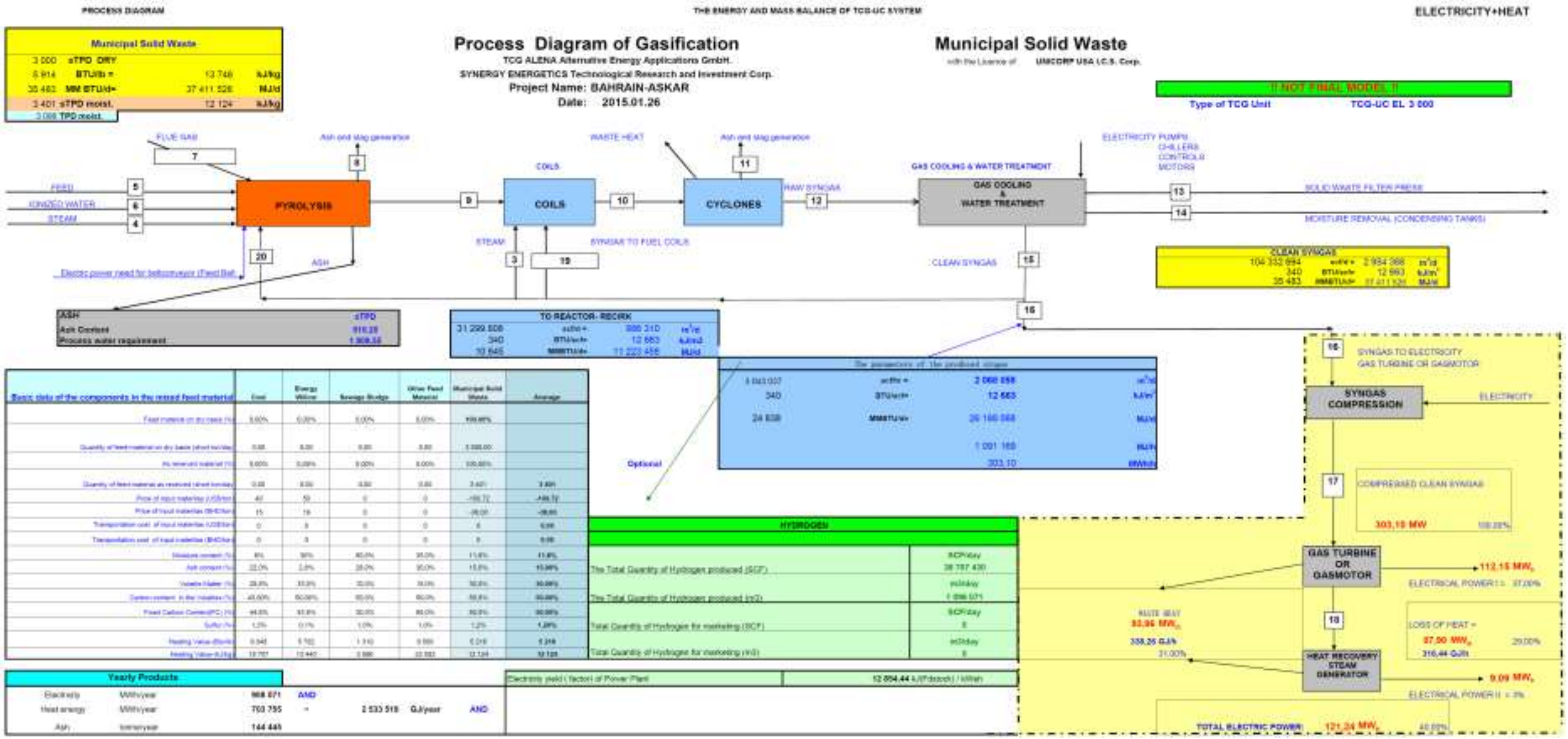
General Description and Offer of TCG-UC System for application of organic wastes to produce energy		
	Feedstock Material	500
BAHRAIN-ASKAR	Municipal Solid Waste	sTPD Dry
	Final Product: ELECTRICITY+HEAT	





6.3.2. The Material Flow Sheet, and the Financial Model of the TCG-UC EL3000 Plant

(TCG-UC EL3000 has the seam capacity as the TCG-UC EL1500TH-TPY Plant)



PROFORMA ELECTRICITY — THE PROFORMA OF TCG-UC SYSTEM — The calculation is based on given data and estimated costs — ELECTRICITY+HEAT

Preliminary ProForma 3 401 Short ton per Day using the TCG gasification plant and the TCG-UC System

BAHRAIN-ASKAR Gasification Project

Feeding material: Municipal Solid Waste
Final Product: ELECTRICITY+HEAT

UNICORP USA International Consulting and Servicing Corp.
TCG ALBNA Alternative Energy Applications GmbH.
SYNERGY ENERGETICS Technological Research and Investment Corp.

Type of TCG Unit 3 000

Date: 2015.01.26

Feedstock Material: Municipal Solid Waste
Final Product: ELECTRICITY+HEAT

!! NOT FINAL MODEL !!

INPUT MATERIALS

3000 Dry s.ton/Day	5 216 Btu/Lb	12 124 kJ/kg
365 Scheduled Days/Year	(16,47) BHD/short ton	(28) BHD/ton
85,6% Overall Availability	-	- BHD/ton
7 480 Operating hours/year	(34,47)	(38) BHD/ton
936 225 Dry Short Ton/Year	10,43 MM Btu per short ton INPUT MATERIALS	12,12 GJ/ton
1 488 880 As Received short ton/Year	(3,30) Cost BHD/mmBtu of input material	(3,1) BHD/GJ
(36 582 882) Yearly revenue from Solid Waste BHD/year		
1 495 549 Feedstock quantity tonnyear as received		

Capital Expenditures

Item	Cost (BHD)
Silica and Glass Bubble Plant	18 119 [illegible]
Decor-stones and Brick Manufacturing Plant	13 013 [illegible]
1 800 dry tons per day Gasifier	205 401 [illegible]
Ancillary Equipments for Feedstock	33 730 [illegible]
Ancillary Equipment of the technology altogether	24 483 [illegible]
The price of ELECTRICITY unit	84 966 [illegible]
Contingencies @ 5,00%	21 770 [illegible]
Total Project (Entire Project)	419 525 184 BHD
Daily cost	[illegible] BHD

Payment schedule

Installment (%)	Sum (BHD)	Proposed period of payment
40%	164 210 [illegible]	In 3 weeks after contracting
30%	123 157 [illegible]	120 days
20%	82 105 [illegible]	180 days
10%	41 052 518	180 days
Total	419 525 184	

Annual Operating Costs

Syngas Production for Sale

81 670 776 revenue BHD per year from all the products

Annual EBITDA

40 736 496 BHD EBITDA

Capital

Salary and Labor costs

Daily Cost

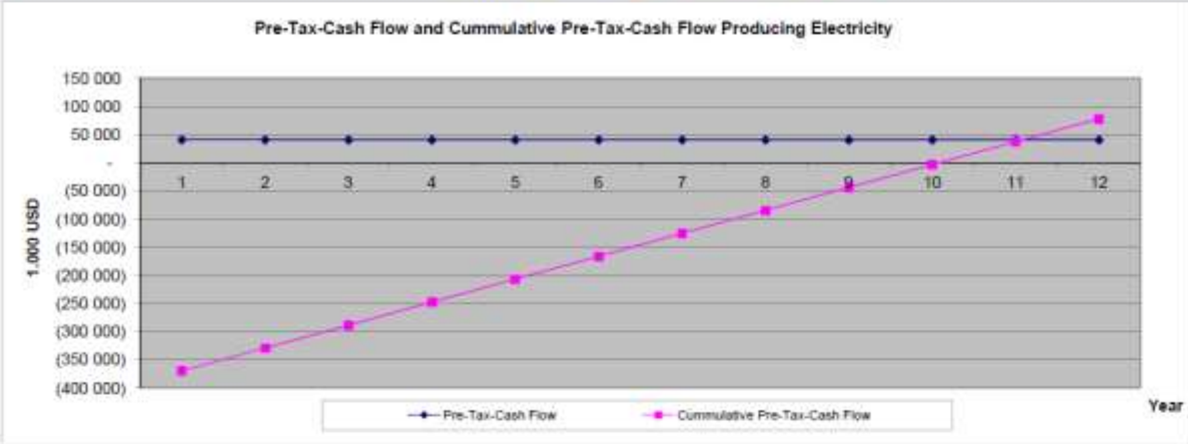
Daily Income

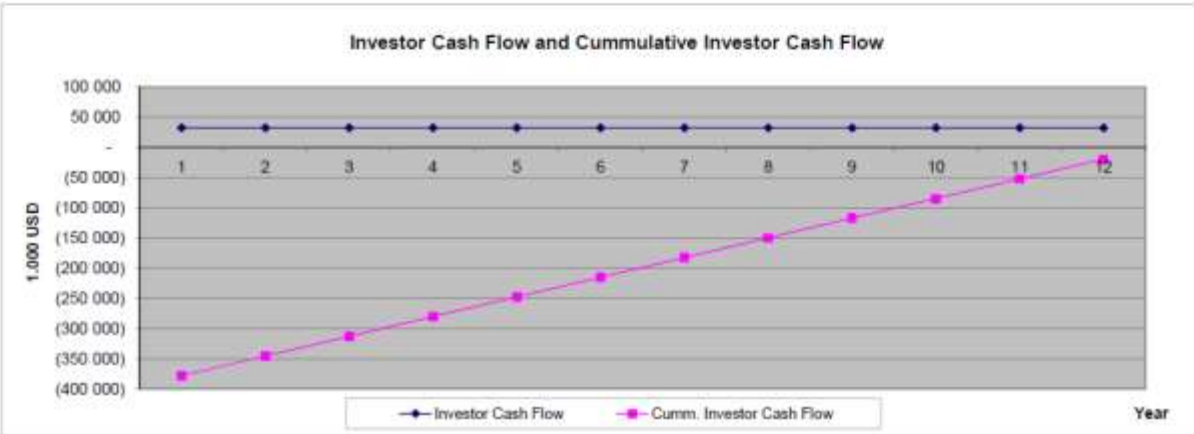
Daily Surplus

Yearly

Pro Forma (BHD000)

General Description and Offer of TCG-UC System for application of organic wastes to produce energy		
	Feedstock Material	3 000
BAHRAIN-ASKAR	Municipal Solid Waste	sTPD Dry
Final Product: ELECTRICITY+HEAT		





6.4. Technology and financial parameters of the Project (Summary)

Number of unit =1	**1 Unit**
Total input material (on as received basis) (TPD)	514,00
Total input energy (MJ/d)	6 235 135
Salable produced electric energy ($MW_e h/h$)	20.21
Salable heat energy ($MW_{th} h/h$)	15.66
Salable heat power (GJ/h)	56,38
Total investment requiremen t (BHD)	68 951 986,-
Labor cost (BHD/year)	3 239 010,-
Yearly operation cost (BHD/year)	9 958 435,-
Total income/revenue (BHD/year)	19 742 348,-
EBITDA (BHD/year)	6 544 903,-

Table 6.4.1.

Number of units=6	**6 Units**
Total input material (on as received basis) (TPD)	3 086,00
Total input energy (MJ/d)	37 411 526
Salable produced electric energy ($MW_e h/h$)	121,26
Salable heat energy ($MW_{th} h/h$)	93,96
Salable heat power (GJ/h)	338,26
Total investment requirement (BHD)	410 525 194,-
Labor cost (BHD/year)	16 673 159,-
Yearly operation cost (BHD/year)	61 092 000,-
Total income/revenue (BHD/year)	118 501 655,-
EBITDA (BHD/year)	40 736 496,-
Rate of return (%)	7
Time of return of investment (year)	10,08

Table 6.4.2.

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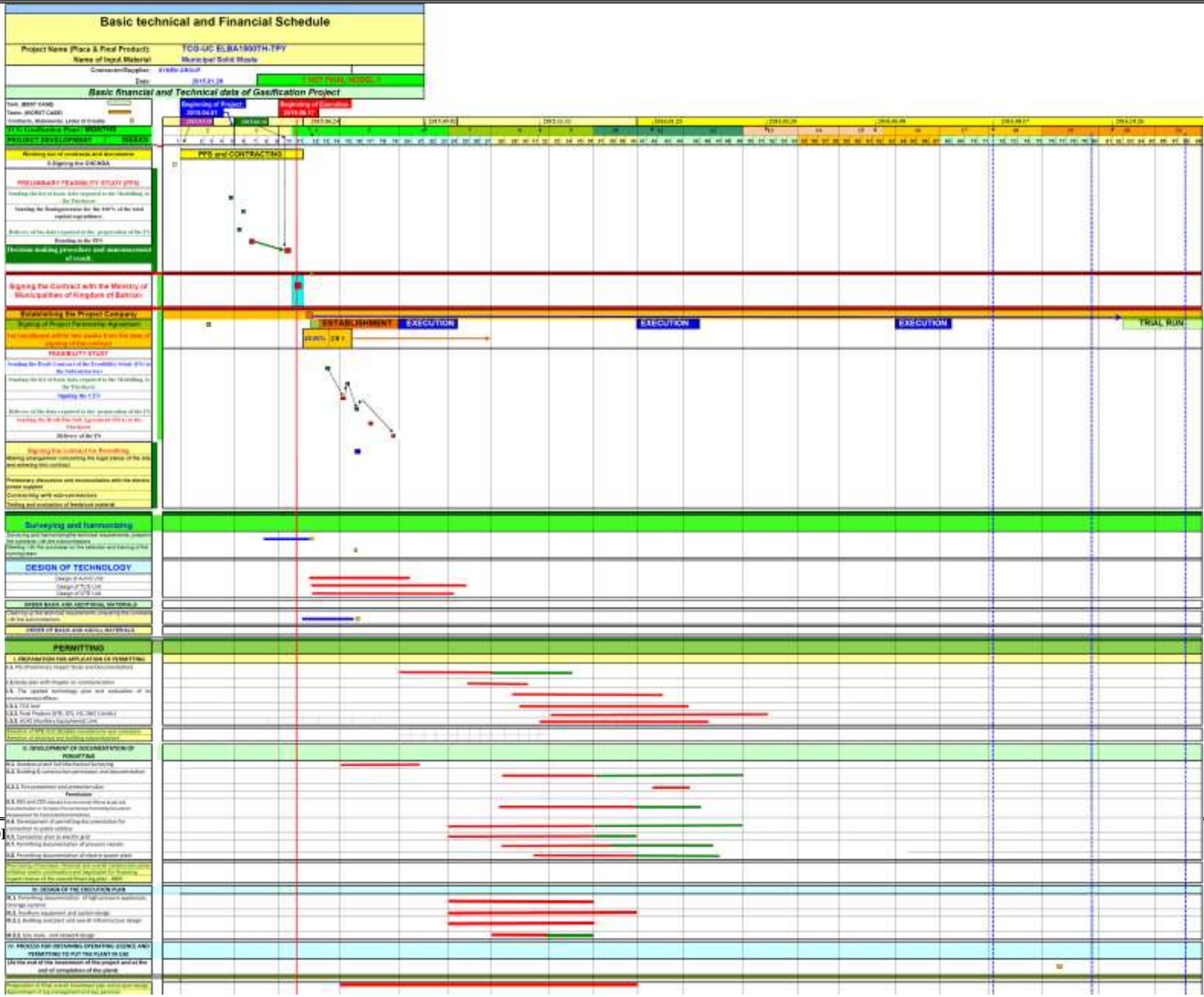
VII. THE REALIZATION PHASE OF THE PROJECT

7. EXHIBIT The schedule of the project realization

TENDERER DOCUMENT

OF

“Provision of an Integrated Waste Management System, Tender no. MUN/20/2014”



TENDERER DOCUMENT

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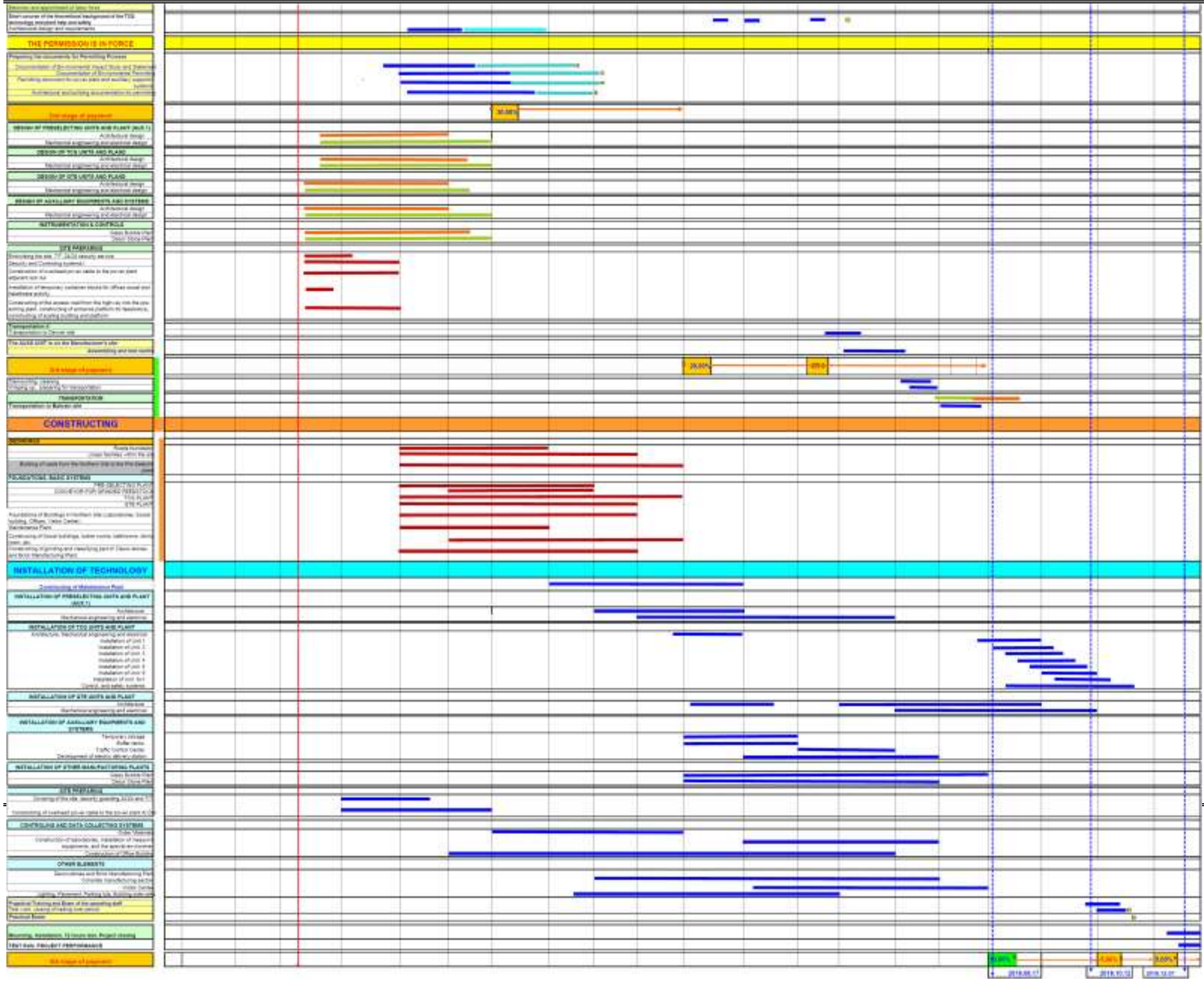

8. View of the Plant

The building and the plant will be designed taking into consideration the local architectural tradition and requirement as much as it can be in harmony with the design requirement and functionality of the plant and facilities. The wishes of the purchaser/supplier will be honored to the maximum extent.

The modern **Bahraini art** movement emerged in the 1950s, with the establishment of an Arts and Literature club in 1952. The club served as an umbrella group for professional and amateur artists, musicians, and actors in Bahrain.[1] In 1956, the first art exhibition was held in the Bahraini capital, Manama. Expressionism and surrealism, as well as calligraphic art are the popular forms of art in the country. Abstract expressionism has gained popularity in recent decades.

History

In 1983, the Bahrain Arts Society was founded when a group of 34 Bahraini artists approached the government and asked for a non-profit cultural organisation to be established.[2] The society hosted multiple exhibitions in and out of the country and offered training in the arts of sculpting, pottery, Arabic calligraphy, painting, interior designing and photography.[1] Most Bahraini artists in the 20th century were trained in Cairo or Baghdad, the cultural art capitals of the Arab world.[1] It was in this period that expressionism and surrealism became widely popular in the country. Arabic calligraphy grew in popularity as the Bahraini government was an active patron in Islamic art, culminating in the establishment of an Islamic museum, Beit Al Quran.[1] The Bahrain national museum houses a permanent contemporary art exhibition.

Architecture

Traditional Bahraini architecture is similar to that of its neighbours. Though the centuries-old forts in Bahrain resemble the same architectural style as in other forts in the Gulf region, the domestic architecture in the country is unique in the region.[4] The wind tower, which generates natural ventilation in a house, is a common site on old buildings, particularly in the old districts of Manama and Muharraq.[5]

A traditional Bahraini house was made up of a series of pavilions around a courtyard. Traditionally, houses had two courtyards (though sometimes only one); one would host the reception of men and the other would be for private living use. The house's rooms were organised in terms of seasonal migration, with the important pavilions for living and hosting receptions having a counterpart on the roof to capture summer breezes and redirect it into the pavilion.[6] The lower rooms of the house would have thick walls, allowing them to be utilised during the cool winter months. To combat the intense heat during the summer months, a framework of coral rubble piers with spaces filled with large panels of coral rocks were erected. The light-weight and porous coral is lined with a coat of lime and gypsum, and this causes warm air to be trapped in the spaces during the day.[6] Hundreds of buildings with this feature were built in Bahrain but virtually none currently function, with most not being repaired or serviced in several decades. A disadvantage of the coral used is that its core is made from clay, as a mortar, and dissolves easily thus causing cracks to develop in the walls during rainy weather, compromising the structure's stability and requiring yearly maintenance.[7]

Following independence and the oil boom of the 1970s, Western-style office buildings were build in the financial districts of Manama, particularly in the Diplomatic Area.

Figure 8.1. The impressive Bahrain Architecture 1A

Figure 8.2. The impressive Bahrain Architecture 1B

Figure 8.3. The impressive Bahrain Architecture 2

Figure 8.4. The impressive Bahrain Architecture 3

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9. EXHIBITS

Considering the requirements determined by the issuer in the "Tender documentation", there are listed only the relevant Exhibits of the TCG BAHRAIN Project

Exhibit A:	**Letter of intent**
ExhibitB:	Contractors qualification
Exhibit C:	
Exhibit D:	Time schedule of performance
Exhibit E:	Preliminary of the system of Partners and subcontarctors
Exhibit F:	Finacial offer – cost per tonne
Exhibit G:	Preliminary ProForma
Exhibit H:	Gasification Process Diagram
Exhibit I:	Mass flow sheet of feedstock

10. Summary

When small groups of scientists and engineers a few decades ago raised the most important issues and problems related to the continuously increasing quantity of municipal and industrial waste materials around the world and in the oceans, perhaps in general terms they presented the answers as well by calling the at-that-time unresolvable problems and the possible apparatus that may solve them "Stargate".

In human history, we can distinguish various ages such as the Copper, Bronze, or Iron Age. In a similar fashion, our present time could be called the "Plastic Waste Age" due to the immensity of plastic waste gathering around the world and in the oceans.

The awesome quantity of plastic waste, exacerbated by animal and human waste containing pathogens that are immune to many present day pharmaceutical products, present an insurmountable problem in terms of environmental and health hazards that cannot be remedied with environmentally-friendly solutions. The "mega-cities" are suffocating under the solid waste handling and disposal problems that are aggravated further with the quantity and quality of the organic sludge from the waste water treatment plants. The presently applied solutions cost the cities and communities many millions of dollars, aggravating the already dire fiscal and economic situations around the globe.

The Earth is a living inorganic and organic ecosystem that contains a tremendous force to keep the equilibrium or re-establish the equilibrium if any natural or man-made catastrophe or significant intervention disturbs that equilibrium. Nations are ready to accept higher prices of producing and maintaining the energy supplies, agricultural and biological needs of their contemporary societies in order to assure similarly livable conditions for their children and the subsequent generations. Such forward-thinking societies continuously invest huge financial resources to develop new environmentally friendly technologies that create the least hostile interference with the environment.

TCG, Thermo-Chemical Gasification is technology that provides the best environmentally friendly solutions, providing not only technological advantages but economic ones as well, because it utilizes waste material that is a renewable resource and at the same time provides a solution to the both huge waste management, handling and disposal problems for all cities and communities.

CONTRACTOR Energetic T.R.I. Corp. is committed to further develop, promote and market not only TCG technology and plants, but similarly highly environmentally friendly technologically and the most advanced energy-related technologies, such as producing a user friendly and "free from electric shock" electricity and electricity inverters.

The geological, geographical, meteorological, cultural and local conditions and customs significantly influence the best technology and system that best suits the local, financial and cultural conditions. Therefore, the company developed and endeavors to continually expand its network of representatives and brokers around the world in order to serve most closely the interest of the local communities, and to carry out market surveys and project development activities. Being close to the customer/purchaser assures effective and clear communication between the company and the prospective customer and assists in the timely development of the project. The project has significant positive effects on the local job market, social, educational and humanitarian program developments.

The Advisory Board (AB) of the company consists of highly educated, experienced scientists, engineers, financing and marketing professionals with the highest professional integrity. The AB assists the company's executives in determining the viability of the projects, and guides the company on the road to further development and unparalleled success.

TCG technology is not merely one solution among the many, but it is that special solution that provides the best presently available answer to the problems associated with the environmental contamination problems that the presently huge levels of urban waste—the millions of used tires, the medical wastes, the almost unmanageable organic industry waste handling and remediation—creates for society. TCG plants emit no harmful or toxic contaminants, the processing units have no chimneys, therefore during the conversion of the carbonaceous materials into energy, the system has no liquid or gaseous material emissions into the environment.

We are very pleased to have this opportunity to submit our application of proposal to this very important project - and we hope we will be having the honour to take part in the execution as well – in such a very important project that can set a high standard for many other eco-, and environmental conscious professionals, politicians and leaders of other countrie.

As many of us know well, we are only custodians of the World what we got from our parents and we must have the responsibility to pass it on to our children and their children's children in the best possible condition

Prof. Robert I. Hargitai

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