

Contact information

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Subject: Vanguard Renewables 520 scfm biogas to RNG

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1. Introduction/Welcome

DMT has a long history of treating biogas and landfill gas. Since the founding of the company by Mr. Dirkse in 1987 we have been building biogas and landfill gas treatment plants. Some of our products are biogas dryers, chemical desulfurization, biological desulfurization and upgrading units.

Currently, DMT has about 55 employees who strongly believe in the future of renewable energy. Each employee is focused on our challenges of creating a green and prosperous future. They play a crucial role in the development of renewable energy business by applying new technologies and implementing smart and simple environmental solutions. Please have a look at our company video at: <http://www.youtube.com/watch?v=ONSnWhm5J3Y>. We have two biogas upgrading technologies in our program. The first system is based on high pressure water scrubbing; the DMT Carborex® PWS and the other technology is based on membrane separation; the DMT Carborex® MS. For your project we propose the DMT Carborex® MS. This system is easy to operate, economical and one of the most flexible systems on the market today.

The biggest advantages of the DMT Carborex® MS are:

1. Flexible and robust design with varying contaminant concentration of biogas
2. Flexible operational biogas flow capacity
3. Highest uptime to gas grid
4. High methane recovery
5. Quick start-up to meet gas grid specification
6. Plug and play model
7. Easy to operate
8. Containerized, compact and small footprint
9. Easy to protect against extreme weather condition
10. Little civil / ground works
11. More output due to less variance in outlet quality

This solution is part of our philosophy. Our team has the ambition to create a clear and prosperous future. We develop smart technologies that benefit our planet and its people. Our innovative designs, plants and service distinguish themselves in quality and return on investment. Indeed we want to contribute to a sustainable future without making concessions to prosperity. Doing this we always focus on human consequences. We consider the quality of cooperation with our clients and exchange of knowledge with our partners as essential. We achieve this thanks to the efforts of our greatest capital: our team of enthusiastic people who continuously strive to improve themselves. This is not just words. DMT operates on the successful 'Big Five for Life' principle. This principle combines the five most important goals of each employee with the five most important goals of our company in order to create a green and prosperous future.

2. Commercial Proposal

This quotation is open for acceptance for a period of 60 days from the date of this offer.

2.1 Operational Data

2.1.1 Methane loss

The estimated methane loss for this project is about 2.5-3.0%.

2.1.2 Availability

The general availability of the plant is 98%. Availability is the percentage of time in a calendar year that the plant is available to process biogas according to the agreed specification and deliver clean gas according to the agreed specification or during which there is a relief event. Availability is defined to start 3 months after the plant is handed over. DMT has to have access to the plant and operational data and logbooks. The customer should have a service contract with DMT to ensure good operation and maintenance. Recommended spare parts should also be available.

In table 2.1 below you will find the specification of the raw biogas and the calculated clean gas specification of the DMT upgrading plant for your project.

Table 2.1 Operational Data

	Biogas IN	Gas OUT	Unit
Flow	300-520	165-345	scfm
Average flow:	270,000	180,000	Mcf/year
CH ₄	55-65	>96	%
Calorific value		>970	btu/ft ³
CO ₂	35-45	<4	%
H ₂ S (average)	500	<4	ppm
VOC	200	<4	mg/Nm ³
Ammonia	150	<4	ppm
O ₂	Negligible	Negligible	%
N ₂	Negligible	Negligible	%
Dew point	Saturated	<7	lbs/MMSCF
T	77-95	77-95	°F
P	0.1-1.0	220	psi (g)

In order to determine the exact performance of the offered unit, it is imperative that the customer submits a complete raw biogas analysis (gas chromatograph). If such analysis is not available we advise you to take a sample as soon as the biogas digester is running at nominal flow. Any performance guarantee claims can only be assessed if a full gas analysis is available. Gas components present in the biogas, which are unknown to DMT at the time of signing the contract, can have an unknown effect on the system.

Table 2.2 Consumables

Consumables	Value	Units
Installed power	280-300	kW
Maximum power consumed for 230 psi(g) RNG discharged*	200-250	kW
Activated Carbon for H ₂ S**	70-80	lbs/day
Media for NH ₃ & VOCs**	95-105	lbs/day

* Power consumption includes blowers, chillers and biogas compressor

** Media Price ≈ 1.5-2.5\$/lb;

2.2 Site Condition

Table 2.3 Site Conditions

Country / location	USA/Vermont
Temperature	-15 to 100 F
Relative Humidity	20 – 80 %
Elevation	300-500 ft
Supply voltage	3 phases, 4160V/480V/120V, 60 Hz
Skid mounted:	Dimension*:
Pretreatment	20 ft x 10 ft
Media Vessels for VOC & NH ₃	20 ft x 15 ft
Media Vessels for H ₂ S	20 ft x 15 ft
Biogas compressor	20 ft x 10 ft
Carborex-MS	45 ft x 15 ft

* Estimated, the footprint is preliminary and subject to change during detailed engineering

2.3 Scope of supply DMT and Client

In this chapter the scope of supply on both the side of DMT Clear Gas Solutions (Table 2.4) and that of the customer is given (Table 2.5).

Table 2.4 Scope of Supply DMT

Item	Description	In scope of supply
1	Pre-conditioner	Yes
2	Biogas boosting	Yes
3	H ₂ S removal	Yes
4	VOC and NH ₃ removal	Yes
5	Biogas feed compressor	Standard
6	Compressed gas treatment	Standard
7	DMT Carborex MS	Standard
8	Vacuum pump	Yes, if needed based on final engineering
9	Gas analysis equipment	Standard
10	Piping, cabling, instrumentation	Standard within the containers/ skids
11	Housing	Skid mounted
12	Containerized Carborex MS	Yes
13	Control system	Standard
14	Documents	Standard

Table 2.5 Scope of Supply Client

Item	Description
1	All civil works
2	Mechanical & Electrical Installation outside the battery limits
3	Cable ducts outside skid
4	Lightning protection
5	Heat tracing and insulation of the piping and skids
6	Piping and cabling outside the battery limits
7	Sewerage connections for condense water
8	Power supply as per the needs of DMT
9	Distribution switchgear and transformers.
10	Coordination, Arc flash and Harmonic Study
11	First fill of Media
12	Calibration gasses for calibrating measurement equipment.
13	Inert gases, for flushing the equipment during start up and maintenance
14	Compressed air for actuators, 87 psig
15	Stable internet connection for VPN connection

Table 2.6 Services that are included in the offer

Item	Description	In scope of supply
1	Transportation to the site	No
2	Supervision of assembly of the plant on site	Yes
3	Assembly and supervision of assembly on site	No
4	Commissioning, start-up of the plant and training of operational personnel.	Yes

2.4 Delivery Schedule

Table 2.7 Delivery Schedule

Steps	Weeks ^{*1}
Detailed engineering and lay-out drawings	8-12
Approval	12 -15
Purchasing/start production	15
Production	15-31
Test running	31-35
Ready for inspection (FAT)	35
Ready for shipment	35
Assembling on site	35-40
Site Acceptance Test (SAT)	40
Commissioning / start up	40-44
Operational Acceptance Test (OAT)	45

^{*1} Amount of working weeks after written order. This is our standard schedule; a quicker delivery time can be arranged depending on mutual agreement between the customer and DMT.

2.5 Payment Schedule

DMT Clear Gas Solutions will require a guarantee of payment. This can be achieved by an insurance, an irrevocable letter of credit or any other means which needs to be discussed upfront.

Table 2.8 Payment Schedule

% of Contract value	Moment
30%	Down payment at order
40%	Down payment at the start of procurement
10%	On materials after completion of FAT* ¹
10%	Down payment at delivery on site
5%	On completion of SAT* ² However, maximal 30 days after FAT
5%	On completion of our commissioning and OAT* ³ However, maximal 90 days after the SAT
100%	For supervising, testing, start-up, etc. after start-up
100%	For spare parts at delivery

*¹ Factory Acceptance Test - 5.5.1 *² Site Acceptance Test - 5.5.2 *³ Operational Acceptance Test - 5.5.3

2.6 Prices

Table 2.9 Prices (USD) VAT, sales tax and other levies excluded.

Description	Price (\$)
Price for:	
- one (1) 520 scfm Pre-treatment skid includes the dehydration, boosting, chillers and controls & instrumentations	
Price for:	
- one (1) 520 scfm VOC and Ammonia removal skid treats VOC & NH ₃ down to <4ppm includes two vessels piped in lead-lag formation, with ladders, platforms and instrumentation	
- one (1) 520 scfm H₂S removal unit treats H ₂ S from 500 ppm to <4ppm* ¹ includes two vessels piped in lead-lag formation, with ladders, platforms and instrumentation	
Price for:	
- One (1) containerized DMT 2-stage Carborex MS® 520 scfm including biogas compressor, post compression filters, dryers and instrumentation & controls.	
Supervision of assembly of the plant at site* ¹	
Commissioning, start-up, performance test on site* ¹	

*¹Excludes cost travel, hotel and related costs.

3. Process of Delivery/Service

The installation is prefabricated and tested in our works before shipping to the site; the unit is then partly disassembled and packed for shipping. On site the unit will be reassembled.

We recommend using local workers for installation and assembly. In good cooperation with the client and with a well scheduled plan this will take approximately 7 days, depending on the local conditions.

3.1 Transport to the site

Transport means that DMT will transport the plant to the site.

In scope of supply: No

3.2 Supervision of assembly of the plant on site

The client will organise local companies/businesses to assemble the plant, DMT will supervise by sending a supervisor.

In scope of supply: Yes

3.3 Complete assembly of the plant on site

DMT will organise a supplier for the plant assembly at site and will take care of the supervision.

In scope of supply: No

3.4 Commissioning, start-up of the plant, and training of operational staff

A DMT engineer will stay on site for final testing, start-up, and instruction/training of operating personnel for a period of approximately 7 working days.

Before start-up the plant we need to have a full analysis of the available biogas (gas chromatograph).

In scope of supply: Yes

3.5 Acceptance Tests

3.5.1 Factory Acceptance Test (FAT)

A factory acceptance test is carried out for the customer in the workshop.

3.5.2 Site Acceptance Test (SAT)

After installation a Site Acceptance Test is carried out for the customer onsite.

3.5.3 Operational Acceptance Test (OAT)

After installation, commissioning, and start-up of the plant according to the DMT manual, there will be a performance test. The performance test usually takes up to 4 working days, during which the gas flow and gas composition have to be stable and all necessities such as gas, power, water and analytical data are available as determined by an independent party. In case of non-performance the company DMT will be given a reasonable amount of time to investigate the non-performance and take the necessary actions to get the process within the specified limits. If during the investigation it is found that the cause of the non-performance is outside of the responsibility of DMT, all extra costs for DMT personnel will be charged.

DMT will provide a protocol for this performance test. Results of the performance test will be reported by DMT.

Any visits by DMT engineers outside of the scope mentioned above, for instance for analysis, trouble-shooting, instructions, maintenance, etc. will be charged.

4. Service & Maintenance Plan

In this chapter you will find the detailed description of the main service items offered in this proposal.

4.1 Service and Maintenance Options

4.1.1 Availability for operational support

In case operational issues arise during the daily operation of the biogas upgrading plant, the operator might need support from DMT in order to detect and solve the problems. By including the 24/7 "operational support availability" feature, remote access to the installation and operational support via telephone will be provided at any hour of the day. The cost of any process technical support will be charged subsequently. An adequate internet connection should be provided by the customer.

4.1.2 Reporting

Regular written reports of your biogas upgrading installation can secure a consistent documentation and a smooth and continuous follow up of the system performance throughout its lifetime. By including this option DMT will log in at least weekly to monitor the performance and pro-actively suggest actions for process optimisation along with a monthly report.

4.1.3 24/7 Call out support

If operational problems occur, immediate troubleshooting can be crucial in minimizing the down time caused. Including the "24/7 call out support" option will secure access to prompt troubleshooting by DMT. After notifying or reporting the failure if required a site visit will take place within 12 hours. The call out support is provided by at least one engineer (only for emergency repairs). Service hours and travelling time costs are subsequently charged on a case by case basis.

4.1.4 Service visits

In order to ensure maximum availability and uptime of the installation, periodic service and maintenance by professionals should be performed according to the manual. With this service feature DMT will organise two service visits per year according to the maintenance requirements of the installation. Regular maintenance will be performed and/or work by sub-contractors will be organized and supervised. All sensors will be calibrated and wear parts and consumables will be replaced. If required the oil of the compressor(s) will be replaced. DMT will arrange the timely order and delivery of the wear and tear parts as well as service consumables such as compressor oil, oil separators and filters that are required for the service visits. After every service visit the client will receive a detailed report on the mechanical condition of the system along with the recommended actions. This option is including travelling time and costs.

4.2 Scope of Supply

The Operations and Maintenance offer includes the service options listed in the table below. In Chapter 5.1 you can find a detailed description of each service item. “YES” or “NO” next to a service item means that we do or do not include this option for your project. “Optional” means that we can offer or have offered this service item optionally and the customer can decide whether or not it is desirable to include it.

APPENDICES

A – DMT Biogas Upgrading Process Components in detail

B – Operation, Maintenance, and Recommended Spare Parts

C – Design Standards and Specifications

D – References

E – Closing statement

A. DMT Biogas Upgrading Process in Detail

Biogas can be produced from different sources such as anaerobic digestion or land fill. This gas has a lower calorific value than natural gas. If the calorific value is increased, it may be used for the same applications as natural gas. Increasing the calorific value is also referred to as upgrading of biogas and mainly involves the removal of CO_2 , H_2S and H_2O from the raw gas of the land fill or anaerobic digestion. It is common to feed the upgraded biogas into the public natural gas grid, but using the gas as vehicle fuel is also a very economical way of using this gas

Biogas boosting

A biogas booster will be installed to increase the raw biogas pressure.

Pre-conditioner

The dehumidification will take place by cooling down the gas to a temperature and dew point of 50F. The pressure drop through the pre-conditioning will be approximately 0.5 psi(g)



H_2S Removal Step

Hydrogen sulfide is removed using carbon filters skids. The system includes two vessels and all the necessary interconnecting piping to allow for lead-lag operation. The media proposed for H_2S removal is a catalytic high capacity media which efficiently converts H_2S into elementary Sulfur. This media will provide the highest performance and autonomy for this application.

Again the pressure drop through the system will be 0.5 psi(g)

VOC and Ammonia Step

VOCs and Ammonia are removed using carbon filters skids. The system includes two vessels and all the necessary interconnecting piping to allow for lead-lag operation. This media will provide the highest performance and autonomy for this application.

Again the pressure drop through the system will be 0.5 psi(g)



DMT Conditioning and Polishing Skid

Biogas Compressor

The biogas compressor(s) will bring the pressure of the biogas to system pressure of 232-250 psi(g), the temperature will increase to 220 F.



Feed Gas Compressor

Compressed gas treatment

The compressed gas will go through a series of filters to condition the gas for the membrane system: Gas temperature will be lowered to 40-45°F.

DMT Carborex® MS

The principle of membrane separation is that the components of a gas mixture are separated by the difference of solution-diffusion through a polymer. The level of separation is determined by the flux of CO₂ through the membrane. The permeability of various components like CO₂, H₂O and H₂S compared to CH₄ gives the selectivity (α) of the membrane. The selectivity depends on the characteristics of the polymer used for the membrane.

DMT has chosen high selective membranes for the highest selectivity (CO₂/CH₄) and the lowest recycle of landfill gas. The high selectivity number (50) yields better CO₂ removal performance compared to

other membranes. Also, the high selective membrane has the ability to remove partial N₂ and O₂ which decreases the sizing of bulk removal of nitrogen and oxygen removal system. Because of lowest recycle of landfill gas (20 -35%) compared to all other membrane products (50 – 60%) in the market, this in turn reduces the power cost and the sizing of the feed landfill gas compressor.



DMT Carborex MS membrane skid

Vacuum blower

A vacuum pump could be installed to lower the pressure of the permeate (CO₂-flow) of stage 2 depending on the outcome of the final engineering.

Gas analysis equipment

The following analysis and/or indicators are included in our delivery:

	Principle	Scale	In scope of supply
Flow raw biogas	Thermal		No
Flow clean gas	Thermal		Standard
Flow off gas	Thermal		No
Methane content clean gas	Calculated	80-100%	Standard
Methane content off gas	IR	0-5%	Yes
Carbon dioxide clean gas	IR	0-5%	Yes
Oxygen content clean gas	EC	0-10%	Yes
Dew point in the clean gas	AOMS	-150 to +70	No
H ₂ S content raw biogas	Chemical	0-50 ppm	No
H ₂ S content clean gas	Chemical	0-50 ppm	Yes

Optional instrumentation package includes all instrumentation for a complete mass balance: Mass flow, CO₂ and CH₄ throughout the system (inlet, outlet, and stack). Mass flow recycle. H₂S, O₂ at inlet and outlet. Dewpoint at outlet.

Interconnecting piping, cabling, instrumentation

Delivery of the system (plant Carborex®MS) includes piping, cabling and instrumentation within the skid/container. The design and construction of piping between the skids is not included in DMT's scope. The design and construction of electrical cabling is not included in DMT's scope.

As per ASME B31.3: Piping components consist of pipe, fittings, bends, flanges, gasket, valves and special components. Any piping components outside of the flange connection on our skid or container are for the client unless explicitly specified as scope DMT.

Delivery

Delivery includes assembling of the standard plant in containerized skid mounted Carborex MS, skid mounted carbon filter with separate compressor on a skid.

Control system

The biogas upgrading plant is controlled by an Allen Bradley PLC (UL listed) with a local interface. The local control system with Human Interface is situated in the control area (the client should purchase an external PC setup to be located in an external office, running the VPN to be communicating with our system. This is suggested for a safe operation of the plant.)

This set-up will handle all digital and analogue signals from the field mounted instrumentation and controls all the pumps, valves and other controlled equipment of the upgrading system.

The control system can be accessed remotely through a VPN internet connection provided by the client or contractor. Data logging is organized by user friendly Scada (Allen Bradley) system.

Some of the functions of the Operator Panel are available by remote control, using internet connection and log-in allowance. The connection from local to remote operation can be established by modem or Ethernet (LAN). The structure of the Operator Panel Menu, showing all displayed as well as changeable values, operation functions and other possibilities of the panel are given in a separate document called "Operator Panel Menu, that is part of each individual DMT gas upgrading system.

DMT will integrate the control of the booster, biogas compressor, but can also integrate the gas to flare valves and the flare for an additional fee.

- Booster, biogas compressor, gas to flare valve and flare: Need to be configured to work on either inlet or outlet pressure. DMT will represent on the SCADA, On/ Off/ Running/ Alarm and show running hours
- Gas to flare valves (hardware out of scope DMT) – DMT can Open/ Close or control % open by PID control.

The main hardware parts of the control system are: PLC, remote I/O and OPC-server.

Transformer, Switchgear, MCC and control panel: Client to provide switchgear to distribute 4160V or 480V power to the skids/ containers. DMT to provide a control panel (non classified) within the (1) Carborex MS container both requiring 480V. From the control panel all transmitters, valves, heaters, pumps and other equipment in scope of DMT will be controlled and powered. The Chiller(s) need to be directly powered from the client Switchgear and the other items out of scope of DMT.

Documents

A hard copy and a digital version of the following documents will be delivered:

1. Project planning
2. Quality and inspection plan
3. P&ID
4. Process description
5. Control philosophy (basic, for operational purposes)
6. Operational Manual
7. Main component supplier manual; layout drawings (2D top vision to indicate location, sizing and connection point for DMT Skids)
8. Customer interface list
9. Equipment list
10. Single line electrical drawings including cable list
11. IO list (including customer signal interface)
12. Instrumentation and load list
13. Education/training plan
14. Certifications as applicable
15. HAZOP

All documents will be delivered in English. DMT will deliver one hard copy and one digital version. Any additional requirements regarding the documents will be charged extra.

B. Operation & Maintenance

Operation of the plant

The installation is fully automatic, but needs to be monitored and inspected regularly by trained operators. Appropriate action might be needed in case of uncommon process variation. The control system watches the plant 24 hours a day. When there is a problem at night or in the weekend the control system can call a service engineer/operator for trouble shooting. All persons who will be responsible for operating the plant must be trained and certified by DMT.

Maintenance of the plant

The maintenance, service and inspection of the plant needs to be done by skilled and trained people. This can be done by DMT engineers and / or can be organized by the client / others which are well trained by DMT. For some parts of the plant maintenance specialists are needed / recommended.

We recommend to contract skilled and professional engineers for this job. Maintenance service and inspection of the biogas upgrading plant should be done by skilled and trained people. This can be done by DMT engineers and/or employees or people involved from client/others which are fully trained by DMT engineers. For some parts of the plant maintenance specialists are needed/recommended.

C. Design Standards and Specifications

This biogas upgrading plant and CO₂ liquefaction unit will be delivered according to standard DMT design, standards and technical specifications complying with general (inter)national regulations and legislations. Piping will be delivered according to US regulations for processing plants (ASME B31.3) and pressure vessels will be delivered including ASME U-stamp certification. The system partly classifies for hazardous zone as per Class I, Div II, Group D.

Other customer's standards and specifications are not known at this moment and therefore not included in this quote. The final P&ID of the process and specifications and brands of the main technical components can be discussed in case of an order.

A DMT employee will be available for two days to execute with our customer a site-HAZOP study (travel time and expenses excl.) Any agreed issues arising from the HAZOP which is solely an effect of the operation of the plant and is within the scope of DMT, and which has a high chance on personal injuries will be solved without additional costs. Safety data of the DMT-plant will be available.

Codes and Standards for manufacturing

ASME Section VIII, Boiler and Pressure Vessel Code

ASME Boiler & Pressure Vessel Code (BPVC) Section II: Materials

ASME Boiler & Pressure Vessel Code (BPVC) Section V: Non-destructive Examination

ASME Boiler & Pressure Vessel Code (BPVC) Section VIII: Rules for Construction of Pressure Vessels Div 1

ASME Boiler & Pressure Vessel Code (BPVC) Section VIII: Rules For Construction of Pressure Vessels Div 2

ASME/ANSI B31.3 Process Piping

ASME B16.5: Pipe Flanges and Flanged Fittings

ASME B16.11: Forged Fittings, Socket-Welding and Threaded

ASME B16.34: Valves Flanged, Threaded and Welding End

API RP-520: Sizing, Selection and Installation of Pressure-relieving Devices in Refineries, Part I Sizing and Selection and Part- II Installation

ANSI/Hydraulic Institute Pump Standards

NFPA70: Electrical distribution and control panels

API RP 500, Electrical Classifications for Gas Processing Plants (Div II)

Standard API RP 540-Recommended Practice for Electrical Installations in Petroleum processing Plants.

Zone 2 Group IIA: instrumentation minimum requirement.

Zone 1 Group IIA: in areas requiring this level of qualification such as near pumps, compressors, relief valves vents and instrumentation vents as indicated in API RP 500.

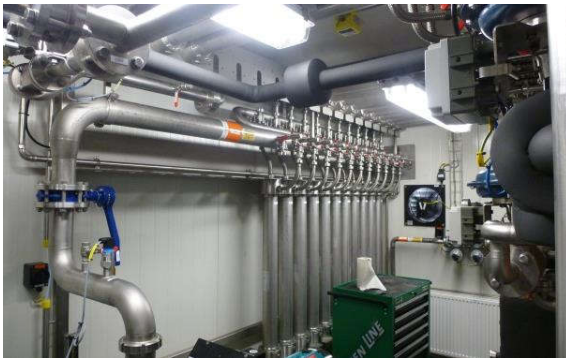
ANSI/UL/CSA B149.6-15 Code for digester gas, landfill gas, and biogas generation and utilization

D. References

DMT has installed systems on a broad range of flows and applications from 30 SCFM raw biogas to over 1500 SCFM raw biogas. We have units that inject the clean gas into the grid but also units which use the clean gas for vehicle fuel (CNG). Below are some pictures of the projects.



DMT Carborex[®] MS in the UK, 500 SCFM raw biogas upgrading for grid injection



DMT Carborex[®] MS in Sweden, 300 SCFM raw biogas upgrading for CNG usage



DMT Carborex[®] MS in the UK, 1500 SCFM raw biogas upgrading for gas grid injection

