

# Philadelphia Gas Works

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January 29, 2010

## VIA FEDERAL EXPRESS

James McNulty, Secretary  
Pennsylvania Public Utility Commission  
Commonwealth Keystone Building - 2<sup>nd</sup> Floor, 1 North  
400 North Street  
Harrisburg, PA 17120

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PA PUBLIC UTILITY COMMISSION  
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RE: Philadelphia Gas Works; 2010 - 2011 Gas Cost Rate Filing; Docket No. R-2010-XXXXXXX

Dear Secretary McNulty,

Enclosed for filing are an original and eight copies of Philadelphia Gas Works (PGW) **Revised** LNG Alternatives Report. The original Report filed on January 28, 2010 did not include the referenced attachments.

Please contact me if you have any questions regarding this filing.

Respectfully,

A handwritten signature in black ink, appearing to read "Gregory J. Stunder", is written over the typed name. The signature is stylized and cursive.

Gregory J. Stunder

Enclosure

cc: All Parties of Record  
Karen Moury, Esq., Executive Director w/enc.  
Robert F. Wilson, Bureau of Fixed Utility Services w/enc.

**PHILADELPHIA GAS WORKS  
2010-2011 GCR PROCEEDING**

**LNG ALTERNATIVES DISCUSSION**

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In Philadelphia Gas Works Joint Petition for Settlement of the Company's 2009-2010 GCR Proceeding (Docket No. R-2009-2088076), PGW agreed to the following in paragraph III.4.:

**III. 4. FEBRUARY 1, 2010 PRE-FILING – LNG ALTERNATIVES DISCUSSION**

PGW has currently contracted for two studies which will explore the Company's LNG alternatives. The studies are expected to be completed by Fall 2009. The Company will present the evaluation of its alternatives in its February 1, 2010 PGC pre-filing. If the Company determines that one of the LNG alternatives is viable, it will also discuss the process by which it proposes to obtain stakeholder approval.

The two studies have been completed and the Executive Summaries are attached. The first study,<sup>1</sup> prepared by Black and Veatch, estimates the cost of downsizing PGW's Cascade liquefaction plant to 7 - 10 MMSCFD. The estimate for the base case of 10 MMSCFD is \$40,000,000. Costs range from \$29,000,000 to \$48,610,000 for the different options. The second study,<sup>2</sup> prepared by CHI Engineering, estimates the cost of a 7 MMSCFD Cosmodyne Nitrogen Cycle Liquifier. This estimate totals \$33,500,000. PGW is seeking estimates for two additional options:

1. A 7 MMSCFD Nitrogen Cycle Liquifier. This estimate is currently being prepared by Air Products. In a preliminary report, the cost is \$32,547,000.

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<sup>1</sup> Attachment 1.

<sup>2</sup> Attachment 2.

2. A small scale liquefier for the liquefaction of the LNG tank boil-off (or an amount that is equivalent to the LNG tank boil-off). This estimate is currently being prepared by Air Products and Linde.

PGW will consider the viability of each option after the two pending estimates are fully completed.

**Executive Summary**

Black & Veatch has conducted a study investigating refurbishment of specific areas of the existing PGW "Pritchard" Cascade LNG plant. The study pinpoints and costs the specific refurbishment needs identified by PGW. This study was based on the following information supplied to Black & Veatch regarding the current state of PGW's Cascade LNG plant.

- Original plant drawings
- Original bill of materials (equipment information)
- Original P&IDs
- Information on all modifications to the process since initial installation
- Information on issues/problems with the current plant operation
- Dresser Rand vendor datasheets for the "new" propane and ethylene refrigerant compressors.

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Based on a review of this information and a plant visit, Black & Veatch conducted a process refurbishment study which includes the following scope:

- Removal and replacement of the existing cold box (exchangers and liquid/vapor separators)
- Replacement of the pretreatment valving skid (dehydration and CO<sub>2</sub> treatment systems)
- Replacement of the existing propane and ethylene refrigerant compressors with a single propane and a single ethylene gas driven compressor.
- Removal and replacement of four cooling water heat exchangers with new air cooled exchangers.
- Removal and replacement of all existing electrical and process control systems, including construction of a new MCC building.

An initial model was developed to simulate the original operating parameters of the existing Cascade LNG process. Subsequent simulation models were created to evaluate the feasibility of installing additional equipment within the existing facility and revising the feed gas / LNG production rate. The models were developed using HYSYS process simulator version 2006 with the Peng Robinson property package (Less-Kessler enthalpy option). To develop the HYSYS models, B&V used the design basis described in Section 2 of this report. The maximum LNG production rate was based on using two new Dresser-Rand compressors. Operating parameters for these new machines were provided by PGW. Based on the reuse of existing facilities, along with installation of the proposed new equipment, a maximum LNG production rate of 6.8 MMSCFD was predicted.



## EXECUTIVE SUMMARY

PGW Cascade LNG Plant Revamp Study  
Rev. 2

To better utilize the existing equipment, a new 10 MMSCFD LNG production model was created. This production case would require additional and larger equipment to be installed, compared to the 6.8 MMSCFD production case. Larger items include new Propane and Ethylene Refrigerant Compressors, as well as a new Cold Box and Aerial Coolers. Detailed LNG production capabilities based on replaced equipment can be found in Section 3 of this report.

B&V contacted two different compressor vendors to obtain sizing and pricing for the 10 MMSCFD LNG production case. PGW's initial request was to replace the existing propane and ethylene refrigerant compressors with a single propane and a single ethylene gas driven compressor. Both vendors were asked to provide quotes for larger reciprocating compressors that would handle the increased flow rate. However, due to the available cylinder sizes, both Dresser-Rand and York were not able to provide reciprocating compressors that could handle the entire flow rate in one train. Therefore, two 50% propane reciprocating compressors and two 50% ethylene reciprocating compressors were quoted. This would result in the need for having a total of four (4) gas engine driven compressors. PGW chose to use this option as the basis for this study. Motor driven reciprocating compressors were also evaluated.

The base case includes two Dresser-Rand propane reciprocating compressors D-R 6-HOS-6 driven by Caterpillar G3608TALE engines and two Dresser-Rand ethylene reciprocating compressors 6-HOS-6 driven by Caterpillar G3606TALE engines.

Black & Veatch has generated a cost estimate for all the base case modifications requested by PGW. Based on the current service contract the developed estimate has a +/- 35% level of accuracy.

The new liquefaction process has the following key parameters and total installed cost (TIC):

	<u>Refurbished Cascade LNG Plant</u>
Feed Gas:	17.53 MMSCFD
LNG Production:	10.00 MMSCFD
Added Fuel Gas (Base Case):	1.35 MMSCFD
Added Electric Load (Base Case):	364 kW
Cost Estimate ( $\pm$ 35%):	\$40.00 MM USD

Selecting four compressors as opposed to two would result in a greater operating flexibility and turndown capabilities. The plant turn down rate could potentially range between 50 and 20 percent. Also, the plant could still operate at a reduced production rate when maintenance is being performed in one of the compressor units.



**EXECUTIVE SUMMARY**

PGW Cascade LNG Plant Revamp Study  
Rev. 2

Also, even though there is a price incentive on the capital cost of four reciprocating compressors, PGW needs to consider the potential higher maintenance costs due to an increase in equipment count. The increase in operation complexity and reduced reliability of reciprocating compressors (versus centrifugal) need to be considered as well.

Additional alternatives were considered such as the use of motor drivers, single Dresser-Rand centrifugal compressors, and York screw and centrifugal compressors. These alternate cases are fully described in Section 10. A price adjustment for each one of these alternatives can be found in Section 8 and 10 of this report.

The use of an electric driver for the selected propane and ethylene Dresser-Rand refrigerant compressors was considered as an alternative to using gas engines. The estimated differential total installed cost (TIC) is shown below:

	<u>Gas Turbine Driver</u>	<u>Electric Driver</u>
Propane Refrigerant Compressor	BASE	(\$0.4 MM USD)
Ethylene Refrigerant Compressor	BASE	(\$2.2 MM USD)

† The estimated installed cost does not include the cost of installing a new sub-station to support the electric drivers.

Even though a price deduction on the capital cost of an electric driver has been provided, PGW needs to consider the increase in potential operating costs due to the increased electric load required by the electric driven compressors. This extra load is estimated to be 5,545 kW.



**COST ESTIMATE**

PGW Cascade LNG Plant Revamp Study  
Rev 2

8.3.1 Additional Options

(US\$ 1,000)

Base Case (Case 1)

\$40,000

- 2 x Reciprocating Propane Refrigerant Compressor (DR 6-HOS-6) with Gas Engines (CAT G3608-TALE)
- 2 x Reciprocating Ethylene Refrigerant Compressor (DR 6-HOS-6) with Gas Engines (CAT G3606-TALE)

Case 2

\$37,400

- 2 x Reciprocating Propane Refrigerant Compressor (DR 6-HOS-6) with Electric Motors
- 2 x Reciprocating Ethylene Refrigerant Compressor (DR 6-HOS-6) with Electric Motors

Case 3

\$48,610

- 1 x Centrifugal Propane Refrigerant Compressor (DR D10R6S) w/ GT (Solar Centaur 40)
- 1 x Centrifugal Ethylene Refrigerant Compressor (DR D10R8S) w/ GT (Solar Centaur 40)

Case 4

\$42,000

- 1 x Centrifugal Propane Refrigerant Compressor (DR D10R6S0) with Electric Motor
- 1 x Centrifugal Ethylene Refrigerant Compressor (DR 10R6S) with Electric Motor

Case 5

\$42,000

- 1 x Centrifugal Propane Refrigerant Compressor (York M538) with Gas Engine (CAT G3608-TALE)
- 1 x Centrifugal Ethylene Refrigerant Compressor (York M438B) with Gas Engine (CAT G3606-TALE)
- 1 x Screw Propane Refrigerant Compressor (York RWB II 676) with Gas Engine (CAT G3606-TALE)



**COST ESTIMATE**

PGW Cascade LNG Plant Revamp Study  
Rev 2

Case 6

\$29,300

- 1 x Reciprocating Propane Refrigerant Compressor (DR 6-HOS-6) with Gas Engine (CAT G3608-TALE)
- 1 x Reciprocating Ethylene Refrigerant Compressor (DR 6-HOS-6) with Gas Engine (CAT G3606-TALE)

Case 7

\$28,200

- 1 x Reciprocating Propane Refrigerant Compressor (DR 6-HOS-6) with Electric Motor
- 1 x Reciprocating Ethylene Refrigerant Compressor (DR 6-HOS-6) with Electric Motor

New Compressor Building

\$800

- Pre-fabricated steel sided building with utilities and crane

Low Emission Burners (Base Case)

\$400

- Low emission burners for Solar Centaur 40 Gas Turbines

8.4 Estimate Exclusions

The following items are not included in Black & Veatch's TIC estimate unless specifically noted otherwise within this document:

- All work outside site perimeter
- Construction power brought to site
- Owner's project management and other owner's costs
- Permanent plant vehicles, fire trucks, maintenance equipment, machines, tools, etc.
- All project financial costs
- All permitting costs
- Letters Of Credit
- Taxation of any kind, duties, fees & withholdings
- Extra forward escalation for volatile metals markets
- Operator payroll by client (including training)
- Building furnishing and equipment
- Disposal of demolition material
- Hazardous waste material removal
- Site remediation or other environmental requirements.

## 1. EXECUTIVE SUMMARY

CHI Engineering Services, Inc (CHI) was contracted by Philadelphia Gas Works (PGW) to prepare a detailed cost estimate to install a new LNG liquefier at their facility in Richmond, PA. The proposed liquefier would be installed in parallel to their existing cascade system, downstream of the existing pretreatment equipment. CHI has developed process specifications and obtained vendor quotes to prepare a detailed cost estimate to procure and install the new liquefier. This cost estimate is based on a factor of +/- 10%.

The following cost estimate is based on the use of either a 7 MMSCFD or 10 MMSCFD Cosmodyne (CDY) Nitrogen Cycle Liquefier and includes the following major equipment:

- Liquefaction Train including Cold Box
- Dual Turbo-Expander Nitrogen refrigeration system
- Nitrogen Recycle Compressor
- Associated Air Coolers
- De-ethanizer column for fuel grade LNG production
- An option has been included for a Nitrogen Makeup System

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## 2. DISCUSSION

The following discussion is presented to support the estimate detail.

### 2.1 Process

The chosen process employs a nitrogen cycle refrigeration system to liquefy dry and CO<sub>2</sub> free feed gas from the existing mol sieve system associated with the current cascade liquefier. The nitrogen cycle, configured with dual turbo expanders is as efficient as any other refrigeration cycle for this size liquefier. The entire process is illustrated in a block diagram found in Appendix A. The process detail is described below along with the piping and instrument diagrams found in Appendix B. The piping system has been designed to meet B31.3 and utilizes trunion ball valves with center drains to provide a double-block & bleed arrangement for maintenance purposes.

#### 2.1.1 PID-1

This PID illustrates the systems for;

- Feed gas from the existing cascade system that has been filtered, regulated for over pressure control, metered, and analyzed for composition and heating value.
- Return gas to the PGW distribution system that is regulated for over pressure control, metered, and analyzed for composition, odorization and heating value. The meter is included for inventory control and mass balance calculations.
- LNG from the cold box that is configured with one thermal relief valve and appropriate isolation valves.

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## 3.2 10 MMSCFD Liquefier Estimate Summary

The following table illustrates a factored estimate for a 10 MMSCFD liquefier.

10 MMSCFD LIQUEFIER ESTIMATE RECAP (FACTORED)				
ITEM	DESCRIPTION	MATERIALS	LABOR	TOTAL
1	EQUIPMENT	\$11,949,714	\$2,167,071	\$14,116,786
2	CIVIL WORKS	\$1,558,587	\$1,274,567	\$2,833,154
3	PIPING	\$891,300	\$1,556,105	\$2,447,405
4	ELECTRICAL	\$1,190,571	\$901,029	\$2,091,600
5	CONTROLS	\$337,875	\$248,143	\$586,018
6	ENGINEERING	\$462,543	\$1,156,571	\$1,619,114
7	PROJECT MANAGEMENT	\$396,000	\$2,434,286	\$2,830,286
8	COMISSIONING	\$498,857	\$218,143	\$717,000
9	TRAINING	\$93,286	\$204,643	\$297,929
10	START-UP	\$58,000	\$235,714	\$293,714
11	PROJECT DATA BOOKS	\$3,571	\$108,857	\$112,429
12	SUBTOTALS	\$17,440,306	\$10,505,129	\$27,945,435
13	ENGINEERING FEE, 5%	\$872,015	\$525,256	\$1,397,272
14	GC FEE, 10%	\$1,744,031	\$1,050,513	\$2,794,543
15	CONTINGENCY, 5%	\$872,015	\$525,256	\$1,397,272
16	INSTALLED COST	\$20,928,367	\$12,606,155	\$33,534,522

## 3.3 Options

Two options are proposed to increase value of the plant, as follows.

3.3.1 A distillation column with re-boiler may be added to the cold box to remove heavy hydrocarbons from the LNG to produce a light LNG that is compatible with an LNG rollover prevention strategy, and any vehicle fueling specification. This item must be added to the original construction as it is fully integrated with the cold box. The price for this adder is \$850,000. CHI highly recommends this option.

3.3.2 A nitrogen production plant can be added to the system to make nitrogen rather than buy liquid nitrogen for make-up to the system. The installed cost of this system would be \$485,000. CHI does not recommend this option.

## 4. SCHEDULE

- The schedule for the delivery of the major equipment is 14 months
- Installation, commissioning, and start-up is estimated at 3 months
- Therefore the total schedule is 17 months from a notice to proceed

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**CERTIFICATE OF SERVICE**

I hereby certify that I have this day served a true copy of the foregoing document upon the participants listed below in accordance with the requirements of § 1.54 (relating to service by a participant).

**VIA EMAIL and FIRST CLASS MAIL**

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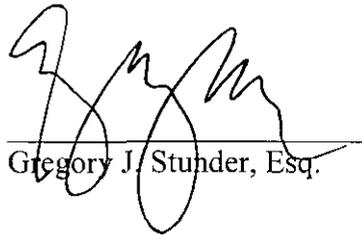
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