

POSTER PAPER



FUGITIVE EMISSION AND LOSS CONTROL FOR OPERATING SAFE AND ENVIRONMENT FRIENDLY NATURAL GAS TRANSPORTATION SYSTEM IN BANGLADESH

Author : Bakht, Delawar P Eng.
Accompanied By : Hussain, Mir Towfiq
Company Name : BETS Consulting Services Ltd.
Country : BANGLADESH
Tel & E-Mail : +88 01714006291, delawar.bakht@betsbd.com
Poster session : WP3
Date & Time : September 17, Wednesday, 12.30-13.30 PM
Venue : "Harlekin & Columbine"
Ground Floor, Tivoli Congress Center
Topic : Transmission & Distribution
Paper Code : WP3-22
Abstract ID : 429



ABSTRACT

The subject research problem encompasses the delineation of the implications of multifold safety, environmental and economic impact of fugitive emission (FE) and unaccounted for gas (UFG) which is commonly termed as system loss in the natural gas industry. The research is primarily based on the relevant statistical information available for a period of over a decade from the Natural Gas Transmission & Distribution Companies of Bangladesh. In fact, natural gas is the prime natural resource of Bangladesh which is in use to serve over 73 % of the countries commercial energy.

Currently, a quantity of 800 billion standard cubic feet of gas, the prime natural resource of Bangladesh is in use per year @ 2300 million standard cubic feet per day (MMSCFD) against the demand of 2700 MMSCFD. The conceptual evolution of UFG, its integrated component of FE & its legacy of impacts have been gaining Tremendous prominence since early 20th century not only because these are eating up the profit of gas marketing companies but also contributing to negative impacts in the climate change since Methane is a Significant component of green house gas (GHG).

It is high time now to appropriately quantify the volume of gas lost in the process of UFG and FE and thus leading to loss control and consequential economic impact. This would simultaneously curve other important factors like potential rise in the safety and hazard issues resulted from both technical inadequacies of the gas operators and non-technical interventions, like pilferage by delinquent consumers. Any positive actions in this respect would automatically be reflected in limiting the environmental change as well.

In this context, the contributions of J. M. Pick ford and F. E. Vandaveer with reference to 1959 AGA Task Force data and that of the findings of Thomas H. and Peacock P.E. on UFG back in Oct. 1919 are recalled. Subsequent studies and research has revealed that the current process of computing UFG & FE is not flawless and therefore it is a prime objective to work out a reasonably acceptable formula which would take in to account maximum possible variables therein. .

1. Preamble

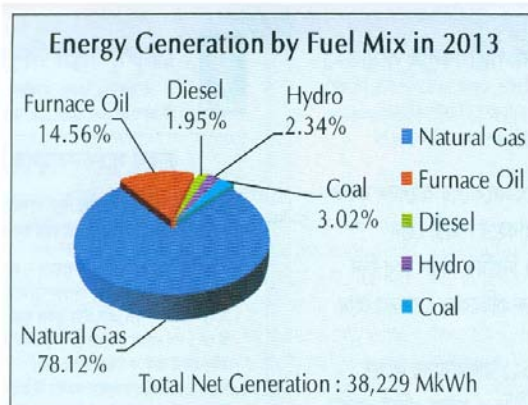
This Paper is basically an update of the research continued further to the presentation made at the World Gas Conference held during 6-9 June, 2006, in Amsterdam, The Netherlands. This has been published in the proceedings of the Conference. Subsequently an Italian version of the said paper has also been published from Milan, Italy in 2009 in the Journal CH₄. Details of the WGC2006 presentation reference of the author is given below for tracking:

4.3 EF.13 Quantum and Implications of System loss in Natural Gas Marketing in Bangladesh: Its causes & Cures – Poster Presentation by: D. Bakht of BETS Consulting Services Ltd., Dhaka, Bangladesh at the Committee Sessions & Expert Forum: WOC 4- Thursday, 8 June 2006, 10.00-12.00, World Gas Conference, 2006 Amsterdam, The Netherlands. WWW.WGC2006.nl



1.1 Current Gas Sector Scenario

Bangladesh, a developing country of South Asia has been operating its own gas industry since 1959. The current scenario of the sector reflects that Gas is being drawn from 2 state owned producing Companies Sylhet Gas Fields (SGFL) & Bangladesh Gas Fields (BGFCL) and 1 Exploration & Production Company BAPEX and 3 IOCs producing fields of Chevron, Tallow, Santos and is served through a Gas Transmission Company (GTCL). This in turn, as of Feb, 2014, being supplied to over 2.5 million customers as fuel and feed stock through 6 marketing companies of Petrobangla viz. Titas Gas (TGDCL), Bakhrahad Gas (BGSL), Jalalabad Gas (JTCL), Pashchimanchal Gas (PGCL), Karnaphully Gas (KGDC), Sunderban Gas (SGDC) and the CNG company (RPGCL).



Market Share of Five Companies under Petrobangla during 2012-13

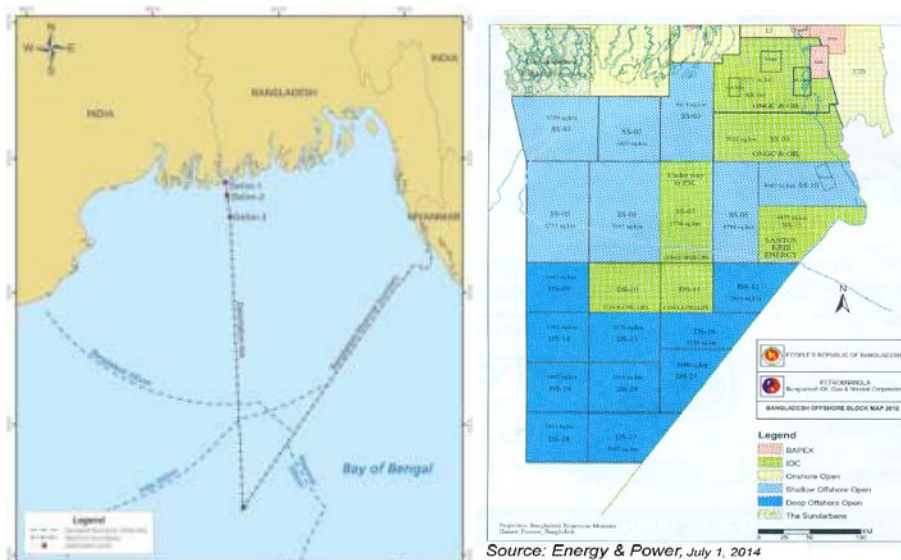


9 gas fields are producing through 93 wells as of April, 2014. Total recoverable (proven + probable) reserve: 27.04 TCF & Total production up to March, 2014: 11.86 TCF and thus reserve remaining is 15.18 TCF. Highest Produced was 2350.40 MMCFD on 21-May, 2014 (Petrobangla: 1,074 i.e. 47% and IOCs under PSC: 1,276.40 i.e. 53%). Now 78 % gas goes to power generation and the rest to the fertilizer

factories, industries, commercial and domestic users and CNG stations. The operating pressure of network system ranges from 950/1000 psig, down to 50 psig. Only 3% domestic customers are metered and the rest are billed on flat rate basis

1.2 Exploration & Production Prospect in the Off-shore Bay of Bengal

The settlement of longstanding maritime boundary dispute between Myanmar and Bangladesh quite some time past and subsequently on 7 July 2014 between India and Bangladesh ushers a new horizon in the relationship of Bangladesh with these two countries. These awards of The Hague based Tribunal constituted under Annex VII of the United Nations Convention on the Law of the Sea (UNCLOS III) have enabled Bangladesh to proceed for exploring and developing off-shore gas blocks. Under Offshore bidding round 2012, 2 PSC have been signed with ONGC Videsh Ltd. and Oil India Ltd for 2 shallow sea blocks and with Santos and Kriss Energy for one block. Moreover, evaluation of bid received for 3 deep sea blocks is in progress.



2. PROBLEM

Major basic objective of the study is to identify the maximum possible number of factors responsible for UFG & FE and also to pin point the prominently contributing reasons and their respective scale of influence on the percentage of Loss & Gain in the UFG in the Gas Industry in Bangladesh. This is primarily for deriving an universal formula for calculation of system loss in gas marketing operations combining cumulative effect of un-accounted for gas and fugitive emission. It is thus expected that the policy context of the study would tremendously contribute to specific management information and hence may bring in a major policy reforms in operating the international natural gas industries in general and that of Bangladesh in particular.

2.1 Deficiency in UFG Accounting Formula

Recapitulating the presentation made in the above mentioned paper on Quantum and Implications of System loss, GASCOR formula of 1997 given as $UFG = \text{Flow in} - (\text{Flow out} + \text{Gas used} / \text{vented} / \text{lost} \pm \text{change- in line pack})$ has been found more relevant and is currently in use for calculation of UFG except adjustment for line packs. It was being tried for a formula with other factors viz condensate equivalence, pressure, temperature and elevation variations, cold gas effect, metering accuracy and tariff loss etc. A numerical model should be available from the study in progress.

Identification of Tangible and Intangible Factors responsible for both Technical and Non-Technical system loss and quantification of impact of these factors on computation of UFG with application of Primary and Secondary Data and appropriate Assumptions.. Innovative Computation of Technical System Loss with the identified variables and quantification of +ve & -ve impacts of these variables are essential for safety & environmental concerns as well as overall loss Control, but these are not duly adopted in practice leaving the deficiency in UFG accounting formula currently in use.

2.2 System Loss Calculation

As in practice at Titas Gas, the UFG means the difference between the gas purchased net of its own operational use i.e., "net through put" and the total sales to different customers. Hence the UFG is = Net through Put - Total Sales.

- UFG is calculated in terms of percentage of volume for convenience.
- The accounting period is considered as one calendar month.

Petrobangla calculates the distribution loss using the following formula:

$$\text{Distribution Loss (\%)} = \frac{\text{RAG} - (\text{Industry} + \text{Commercial} + \text{Domestic} + \text{Others})}{\text{RAG}} \times 100$$

RAGs

Where: RAGs = Rest Available Gas for sales, RAGs = P - (E+F), P = Total Gas Purchase, E = Gas sold to Electricity, F = Gas sold to Fertilizer

3. METHODOLOGY

3.1 Field Data Enumeration & Research over the period 2000-2014

Findings of the research were mostly based on the gas marketing companies of Petrobangla in general and TGTDC, the pioneer & the largest Gas T & D Company of the country in particular and these findings are as follows:

- Current process of computing UFG & FE is neither flawless nor the basic tools like the computation formulae in use are classical and universally applicable.
- No-consideration of salient variables and their values in the UFG & FE computation formulae used both nationally and internationally has substantial non-conformity to recognize the actual state of the art.
- No-substantial steps are visible to enumerate the economic component of environmental damage being impacted by FE and thus GHG, a concern to climate change issues.
- Flaws in the process UFG & FE computation is leading to erroneous and misleading state of affairs and thus barring to taking appropriate remedial actions.
- Legacy of impact of UFG and justification of the study of safety & environment largely depended on analyzing the evolution of UFG and its prominence to assist in devising appropriate mechanisms for efficiency improvement in Gas marketing.
- The depth, dimension and magnitude of the research should transpire the financial loss and focus on the economic component of the environmental degradation. It would also unveil the anomalies done to the customers through system gain for reasons so identified.



- Identification of the flaws and gaps and delineation of the pertinent factors would bring in appropriate modification in the aforementioned formulae.

- Accuracy in computing system loss comprising UFG & FE to equip the gas operators with tools of sourcing out the mechanisms for reducing the multifold impacts of system loss and thus efficiency improvement in Gas marketing operations.

3.2 Factors Predominantly Involved in the Process of Computation Of UFG & FE

Literature Review outcomes from concerned international and national publications are supporting the validity of approximating the variable figures and their potential impacts. These coupled with Author's earlier papers on UFG & FE and the Methane emission studies conducted by some NGOs like ALGAS in Bangladesh depicts the factors and their values as follows:

- Meter errors and leakages
- Temperature difference of 50°F change volume difference of 1%.
- Specific gravity difference of 0.003 for a 0.6 sp. gravity gas causes a change in volume calculation for orifice meters of about 0.25%.
- A change in gas water vapor and oil fog content from saturated to dry will decrease the volume by 1.74% (*Thomas H. and peacock P.E. 1919*),
- Improper plate size and no periodic replacement of meters
- Large meters are incapable of registering small flows.
- An elevation difference of 1000 ft. causes a change in volume of about 3%. Therefore negative UFG is also a possibility.
- Leakages reduce the system capacity in addition to loss of 86% estimated on account of fast and slow meters (*J. M. Pick ford and F. E. Vandaveer 1959*).
- leakage, actual loses & discrepancies due to meter inaccuracies, variations of temperature and pressure and other variables and old pipeline losses up to 5% (*Shell, UK 1993*).
- Loss of 1.6% of receipts with an 11 years average of 2.1% mostly due to measurement inaccuracies, accounting system and theft with
- Small percentage of 0.15% of receipt as emission (*Pacific Gas and Electric, USA 19870*).

The 3 other Papers so identified are:

- Allocation of Unaccounted For Gas , MAUNSELL / AECOM by Guenter Wabnitz, Prepared for: Gas Industry Company, June 2007, www.maunsell.com
- FUGITIVE EMISSIONS FROM OIL & AND NATURAL GAS ACTIVITIES by David Picard, Environment Australia, December 1999 www.npi.gov.au/publications/emission-estimation-technique/.../fgassup.pdf
- Finding Unaccounted For Gas by: E.L. Upp, Ultra Field Measurement Company, www.triad-measurement.com/images/triad/.../findingGAS.pdf

3.3 Potential Policy Implications in Conducting the Research

Keeping in view that the research so undertaken should transpire the flaws so far as efficient operational and marketing management is concerned and with the ultimate aim of deriving new formulae as applicable, the following steps stands important as such :

- a. Assumptions so considered in deriving the proposed new formula
- b. Limitations and constraints of not considering the other remaining factors
- c. Field testing the formula with data of 2000-2014 and recording the outcome of trials & errors
- d. Verification of similitude of these data, methodology and assumptions with that of other identical neighboring & overseas national and international companies.
- e. Extent and limitations of the study to be completed with Results, Summary and Conclusion

3.4 Identification of Nature of System Loss

It has been identified that the volume of gas lost in the process of UFG and FE and thus leading to issues of loss control and consequential economic impact are basically through 2 Types: Technical system loss arising out of technical inadequacies of the gas operators and Non-Technical system loss resulting from non-technical interventions, like pilferage by delinquent consumers. Any positive actions in this respect would curve the important factors like potential rise in the safety and hazard issues and will also automatically be reflected in limiting the environmental change as well.

3.5 Broad Reasons for System Loss & Gain

Reasons for System Loss or Gain in a Natural Gas Transmission & Distribution network system typical as that in Titas Franchise area as enumerated through extensive field works, literature reviews and analysis of primary and secondary data projects. These have revealed that, among other issues, this is partly because:

- Knowingly or unknowingly those salient variables and parameters essential for appropriate UFG & FE computation are being ignored,
- Contractual obligations to a large section of major customers are neither being fulfilled in terms of supplying gas at requisite pressure due to gas crisis and system inadequacies
- Nor most of them are duly compensated through installation of EVC meters and
- Partly because of the fact that about 2 million domestic customers are being supplied with un-metered gas on flat rate basis and the sale volumes for those customers are reckoned on arbitrary figures fixed for single and double burners.

These reasons are beyond the ones that illegal and unauthorized consumption of gas are not included in the books of accounts and emission of gas due to leakages and other system operation and maintenance requirement are not being reckoned with due correctness. The Statement of Gas Purchase, Sales & System Loss is placed in Table-1, the records of Metro Dhaka Emergency Works of TGTCL during May, 2014 is given in Table-2 and Purchase, Sales and Unaccounted for Gas in the Titas Franchise Area for the month of May-2014 in Table-3.

Table-1: Gas Purchase, Sales & System Loss Titas Franchise Area May 2014									
Year/ Month	Total Average	Purchase						SYSTEM LOSS %	
		Volume MMCM	Volume CRORE TK.	Volume MMCM	Volume CRORE TK.	Volume MMCM	Volume CRORE TK.		
2011-2012	Total	13443	3956.68	13612	7025.45	-168.93	-88.82	-1.26	
	Average	1120	329.723	1134	585.454	-14.077	-7.402	-0.10	
2012-2013	Total	14250	4558.96	14246	7337.75	4.12	3.94	0.028905	
	Average	1187	379.91	1187	611.48	0.34	0.33	0.00	
2013-2014	Total	13585	5989.240	13567	6945.090	17.212	8.811	0.127	%
	Average	1358	598.924	1356	684.509	1.7212	0.881	0.01	%
Last 6 Months									
Dec.13		1286	508.85	1194	578.63	91.42	44.27	7.11	%
Jan.14		1313	566.04	1246	633.05	67.00	34.03	5.10	%
Feb-14		1190	539.70	1208	628.97	-18.28	-9.52	-1.54	%
Mar-14		1288	587.07	1269	656.16	19.11	9.88	1.48	%
Apr-14		1227	554.31	1247	652.72	-19.37	-10.14	-1.58	%
May-14		1265	575.43	12707	669.14	-5.25	-2.76	-0.41	%

Table-2: System Operations Division, Metro Dhaka Emergency Works: May, 2014								
Emergency call records		Attended Call Classification		Material Consumption		Remark	Pipe size	Purging Testing & Commissioning In Meters
Types	Nos	Types	Nos	Name	Nos	Call/Day		
Fire	25	Main Line	267	3/4" Regulator (Foreign)	0	Maximum-24 Nos	3/4"	834.61
Leakage	353	Service Tee	1	3/4" Regulator (Local)	60	Minimum-9 Nos	1"	623.54
No gas	59	Domestic Meter	0	3/4" Lock Wing Cock	23	Average-16 Nos	2"	1448.16
Law pressure	7	Lock-wing cock	23	3/4" Compression Coupling	55		3"	977.16
House Line Fault	32	Regulator	60				4"	54.78
False Call	-	Regulator & L Cock	55				6"	15.24
others	12	Riser	35				8"	100.6
		House Line	32				10"	
		R.M.S (C/Ind)	3				12"	
		Others	12				16"	
Total	488		488					

Table-3: Titas Gas Transmission and Distribution co. Ltd.*					
Sales figures based on billed consumption (Unit: SCM)					
Statement of Purchase, Sales and Unaccounted for Gas for the month of May-2014					
1	Purchase:		4.5	Fertilizer:	
	A. BGFCL / SGFCL			4.5.1 UFFL	609269
	1.1 Titas Gas Field	424658649		4.5.2 PUFF	660868
	1.2 Habiganj Gas Field	0		4.5.3 JFCL	36930576
	1.3 Narshingdi Gas Field	24530729		Sub Total	38200713
	1.4 Kailashtila Gas Field	-		Total of Bulk	427075586
	1.5 Beanibazar Gas Field	-	4.6	Non Bulk (Metro Dhaka area):	
	1.6 Srikail	-		4.6.1 Industrial	29714653
	Sub Total (A)	449189378		4.6.2 CNG	29421501
	B. IOCS			4.6.3 Generator	15684187
	1.1 Bibiana Gas Field	724594024		4.6.4 Commercial	8918111
	1.2 J.B & M.B.G Field (Shebron)	59685315		4.6.5 Domestic (Metered)	2663658
	1.3 Bangura	35403683		4.6.6 Domestic (Single-Unmetered)	19899245
	Sub Total (B)	819683022		4.6.7 Domestic (Double- Unmetered)	81454705
	Total Purchase (C)=(B+C)	1268872400		4.6.8 Domestic (Appliances)	753075
	GTCL Own use (D)	4247523		Sub Total	188499135
	Net Purchase (1) = (C-D)	1264624877			
2	Own Use At:		4.7	Non Bulk (RSD area):	
	2.1 GPS RMS	57058		4.7.1 Industrial	266416250
	2.2 SPS RMS	21917		4.7.2 CNG	34073515
	2.3 RPCL RMS	8382		4.7.3 Generator	294870296
	2.4 AES RMS (HPS + MPS)	33357		4.7.4 Seasonal	-
	2.5 JFCL+UFFL+PUFF RMS	13592		4.7.5 Commercial	3216970
	2.6 Others (Dhanua+ Mymondrs)	8495		4.7.6 Domestic (Metered)	2986010
	Total (2)	142801		4.7.7 Domestic (Single-Unmetered)	7410416
					44656815
3	Net Throughput (1-2)			Sub Total	653630272
				Others:	
				4.8.1 To JGTDS (Madhabpur)	-
				4.8.2 Condensate Equivalent	522597
4	Sales			Sub Total	522597
	4.1. Power (Government)	192,065,031		Total of Non- Bulk (4.6+4.7+4.8)	842652004
	4.2 IPP (Government Power Rate)	87,552,702	5.	Total Sales (4.1+4.2+4.8)	1269727590
	4.3 SPP (Government Power Rate)	73,077,091	6.	Unaccounted for Gas (3-5)	-5245514
	4.4 Captive Power Rate	36,180,049	7.	Technical System Loss	15806026
	Total Power (4.1+4.2+4.3+4.4)				1.25%
			8.	Domestic Tariff Loss (As per Proposal)	36429902
					2.88%
			9.	Technical Loss & Domestic Tariff Loss (7-8)	52235928
					4.13%
			10.	Net UFG (6-9)	-57481443
					-4.55%
A.	As per Tariff:				
	Single Burner = 400÷5.165 x 352636				27309661
	Double Burner = 450÷5.165 x 1447480				126111520
				Total (A)	153421181
B.	As per Real Consumption			(Based On Sample Test)	
	Single Burner = 352636 @	8665			30555909
	Double Burner = 1447480 @	8665			159295174
				Total (B)	189851083

6 Pilferage of Gas by Delinquent Consumers

Pilferage of Gas, rather unauthorized connection and thus rampant stealing is causing not only increased system loss under Non-technical category but also creating hazardous situations in the neighborhood of such unauthorized connection activities. Some of the news paper clipping covering Titas franchise area over the last couple of years will further clarify the situation.

	 <p>The caged gas transmission valve, installed by unqualified people, are observed on the front yard of a house already connected to the transmission pipes at Pagaripara in Sonargaon of Dhaka District. After an unauthorized connection taken from the main to the same area and a banner is hung in front of the Pagaripara gas transmission office by the nearby owners and customers of facilities including some gas shops.</p>
<p>Gas Line punctured and caught fire during laying of a internet cable line underground at farm Gate intersection of the City of Dhaka</p>	<p>Caged valve of an illegal Gas connection from Gas Transmission main Line at Ruppaganj with Protest note displayed in front of local gas office for low pressure in the line.</p>
 <p>জালালাবাদ গ্যাস টি অ্যান্ড ডি সিস্টেম লিঃ (সেন্ট্রালিভার এনর্জি কোম্পানী) গ্যাস ডিস্ট্রিবিউশন অফিস, ডিএসও The Daily Star, Feb 6, 2014 তারিখঃ ০৫-০২-২০১৪ গ্যাস ব্যবস্থার মানদণ্ড মেনে এবং সমস্ত গ্যাস নিয়ম অনুসরণ করে। জালালাবাদ গ্যাসের শেইখেরাঞ্চল ৩৫ বর্গইঞ্চি উত্তম মানের পাইপের সেরা ব্যবহার।</p> <p>অবৈধ গ্যাস পাইপ লাইন স্থাপন সম্পর্কে সতর্কীকরণ বিজ্ঞপ্তি</p> <p>সিঙ্গেল, মুনামল্ল, মৌলভীবাজার ও হকিঙ্গল জেলায় অবস্থিত জালালাবাদ গ্যাসের স্ট্রায়া ও ন্যাশনাল গ্রাহকদের অবগতির জন্য জানানো যাচ্ছে যে, জালালাবাদ গ্যাস সিঙ্গেল বিক্রেতার বিভিন্ন এলাকায় স্থাপিত বিভিন্ন নেটওয়ার্কের মাধ্যমে গ্যাস সরবরাহ গ্রহণ করা হয়েছে। জালালাবাদ গ্যাসের বাতম্যকৃত এলাকায় অন্য কোন কোম্পানী বা প্রতিষ্ঠান বা ব্যক্তি গ্যাস সরবরাহের জন্য কোন ধরনের গ্যাস পাইপ লাইন স্থাপন করায় এখতিয়ার বা অধিকার অধিকার নেই।</p> <p>সং ৩০-০১-২০১৪ তারিখে সিঙ্গেল বহুরত্ন সুরমা আহমদপুর এলাকায় তিতাল গ্যাসের টিকিয়ার পরিধারে গ্যাস বিতরণ নেটওয়ার্ক স্থাপন করে পুন্ডিয়ার সহায়তায় হাতে হাতে বাসাবাসসহ একত্রিত করে হয় এবং যার ক্ষেত্রে জালালাবাদ গ্যাস কর্তৃক সুরমা বান্দা বাসাবাসে গ্যাস লাইন স্থাপন ২০১০ এর আওতায় সি.আর.নাম্বার সি.১২/২০১৪ মাধ্যমে করা হয়।</p> <p>এ ধরনের অস্বাভাবিক গ্যাস লাইন স্থাপন বা গ্যাস সরবরাহ সংক্রান্ত পাইপ, নিউক্লিয়ার মাস্টারস কোন ব্যক্তি বা প্রতিষ্ঠানের নিকট মনুদ করা বাধ্যমান গ্যাস লাইন ২০১০ এর আওতায় আর্থিক বা সুরমা বা টিকিয়ার দপ্তর দখলীয় অস্বাভাবিক।</p> <p>এ ধরনের অস্বাভাবিক গ্যাস লাইন স্থাপন, অস্বাভাবিক সম্পর্কে এবং যত্নসহকারে পাইপ লাইনের বাসাবাস সম্পর্কে সুরমা বাসাবাস সিঙ্গেল জালালাবাদ গ্যাসের উত্তম মানের (০১৭১১-০৯০২১৫, ০১৭১৪-০৯০০৮০, ০১৭৩০-০১২০৭৭) অবগিত করার জন্য অনুরোধ করা হলো।</p> <p>জালালাবাদ গ্যাস কর্তৃপক্ষ</p>	
<p>Legal Action Reminded through notification published in the Press by Jalalabad Gas</p>	<p>Illegal Lines are being removed in Narayanganj area.</p>
 <p>These authorities conduct a drive to snap illegal gas connections in Natchikintapur of Gazipur yesterday.</p>	
<p>Gas Line punctured and caught fire during laying of a internet cable line underground at farm Gate intersection of the City of Dhaka</p>	<p>A view of one of the Metering & Regulating Station of Titas Gas T & D Network System</p>

3.7 Current Illegal Gas Connection Scenario

Despite vigilant actions and surveillance by the Gas marketing companies, there has been continuous reporting in the national dailies about the illegal actions by the unscrupulous people in connivance with a section of the employees of such companies. For example, “Prothom Alo” on 23 January, 2014 reported that there has been 200 km unauthorized pipeline laid & 300, 000 illegal connection detected in Titas franchise area, on 6 February, that 12,000 houses have been given unauthorized connections and 10, 000 are waiting for in Sonargaon police station area alone and the general public of the locality are scared of accidents to happen at any time.

The report also included that each customer is taking such unauthorized connection paying BDT 45,000 and thus a syndicate has been collecting BDT 540, 000,000 as such. On 26 April, 2014 it reported that

anomalies in the gas sector was not being under control in spite of police action and disconnection drives conducted by the gas authorities, rather such customers are being re-connected in Gazipur, Keraniganj & Sonargaon areas in absence of further police actions.

Another “Prothom Alo” report of 2nd September, 2014 states that Titas Gas has been continuing their drive in Ashulia of Dhaka sub-urban area to retrieve 5 km unauthorized pipeline with help of police led by an Assistant Commissioner of Civil Administration and removed about 400 ft of 2 inch and 1 inch diameter pipeline and thus disconnected over 100 illegal consumers. It is said by one of the consumers that they had to pay BDT 50,000 to 100,000 per connection and was assured that these would be legalized soon by the Titas authority. But Titas officials conducting the drive said such disconnection would be continued in the area.

3.8 Information on Current Process of Legalization of Illegal Connections

Following Government's declaration that lifted embargo on domestic gas connection, the company has received 1, 64,803 applications for legalizing the illegal gas connections by June 20, 2013, the official declared date for such application. Subject to a few conditions, penalty, payment of bill and security deposit, the legalization process of the applicants, who fall into the following two categories, is already in progress. Firstly, gas connection to the increased number of burners by means of the extension of house line from the existing gas connections. Second category related to the illegal gas connections from the constructed but not commissioned risers. Further similar efforts are being maintained by the other gas marketing companies in publishing notice of warning in the local press. One such notification issued by the Jalalabad Gas in Bengali is shown in this paper.

3.9 System loss Reduction Program:

In the financial year 2012-13 under review, due to sincere efforts put in place by Titas Management under the direction of Titas Board, Petrobangla and Ministry, positive results have been achieved in system loss reduction. Under this programme, to reduce system loss, the company has been conducted special drive to visit regularly to customer premises to disconnect illegal connection of dishonest customers. Through this special drive 3,263 customer premises have been visited and 40 Gas Connection have been disconnected due to various anomalies/irregularities. The premises of the industrial & disconnected customers are being inspected by special teams. System loss of the Company has stood 0.03% in 2012-13. But, If Gas use against 1,64,803 nos. of burners of the confessed illegal domestic customers in a year is taken into account then the company's system gain stands to 1.22% instead of its system loss of 0.03%.

Table-4: Year Wise System Loss within Titas Franchise Area		
Financial Year	System Loss/(Gain)	
	In Volume (MMCM)	In Percentage
2007-08	430.09	3.39
2008-09	109.36	0.81
2009-10	(313.26)	(2.14)
2010-11	(267.46)	(1.82)
2011-12	(186.43)	(1.39)
2012-13	4.12 (173.94) *	0.03 (1.22) *

*Considering Gas use against 1, 64,803 nos. of confessed illegal domestic customers in 1 year.

Source: TGT DCL Annual Report 2012-2013

4. RESULTS

4.1 Reasons for Current +Ve UFG i.e. System Gain

It may be observed from the Table-4 there has been system gain despite a huge number of consumers have taken unauthorized connection of gas from illegally laid pipeline in different parts of the Titas Franchise Area. In depth study of the reasons behind the scene is reveals that:

4.1.1. Billing is not being done on actual consumption basis rather it's based on minimum charge and hence the quantity of gas of the consumers who are not consuming it beyond fixed minimum charge is contributing to System Gain as per computing formula currently in use.

4.1.2. Bills are generated on the basis of approved pressure and not the actual one which is less in the distribution system.

4.1.3. Non-bulk customer's temperature measurement is absent. But in billing system it is considered one. For gas temperature 15o C, the temperature factor is one but in summer gas temperature is more than 15o C and so the temperature factor is less than one.

4.1.4. Metering error accepted range is + / - 2% and if it is always +ve for the customer, he would be losing and UFG would turn +ve.

4.1.5. Compressibility factor is considered for bulk customers, where AGA 8 is followed for temperature corresponding factor, but this are not considered for non-bulk customers.

4.2 Overall Gas System Loss Improvement

4.2.1 The overall gas system loss or unaccounted for gas ranged from 4.5% to 6.5% during FY2000-FY2005 These system losses were much higher than the 2% covenanted for the different gas distribution companies under ADB's Third Natural Gas Development (TNGDP) Project and the experience in most countries in the region.

4.2.2 The distribution losses were very high, ranging from 13 to 21%, while the transmission loses were within reasonable levels, less than 1-2%.

4.2.3 Some improvement has been achieved with the average losses falling to 1.48% reflecting the impact of the measures undertaken in recent years across all gas distribution companies. Factors like meter inaccuracies, pipeline leakage, loss due to flat rate domestic billing, and theft or fraud are believed to be the major contributors of the system losses.

4.2.4 As revealed from their annual report TGTDCCL has initiated several measures under a well defined action plan both technical and administrative to contain the system losses, which include

- Upgrading of metering & regulating stations under TNGDP,
- Strengthening Cathodic Protection,
- initiation of installation of meters to domestic consumers ,
- Increased vigilance,
- Severing of unauthorized connections and drawing legal proceedings against the delinquent consumers.

5. CONCLUSION

5.1 Still persistent gas theft of whatever magnitude by the domestic, commercial and industrial consumers could be reduced by more rigid monitoring and stricter enforcement of relevant regulations. The enactment of the proposed Gas Act has empowered the marketing companies to take more stringent legal actions against fraud, theft, malpractices by the delinquent customers. Further, closer attention to remove the technical inadequacies must contribute to reduce leakages and fugitive emissions from the network system.

5.2 This research document when completed is expected to remove the lack of scientific, engineering and statistical precision in UFG & FE computation formula in practice by the gas marketing authorities of Bangladesh and elsewhere in the world. In fact, answering the following questions would stand pertinent in carrying out further studies to conclude the subject research:

- 5.2.1** What is the draw backs and inadequacies of the respective formula, if any, in appropriately computing system loss?
- 5.2.2** Are all pertinent variables and parameters incorporated in due dimension and magnitude which ought to have been taken in to consideration?
- 5.2.3** What are the common sources of FE in the gas industries and what are the ones applicable in Bangladesh gas industry?
- 5.2.4** What could be the reliable means for quantification of FE from the gas industries and thus what value of FE can be arrived at for Bangladesh gas industry?
- 5.2.5** How UFG & FE have potential impacts in environmental and economic considerations?
- 5.2.6** What are the criteria of evaluating the safety, environmental and economic components of UFG & FE?
- 5.2.7** Field testing the formula so derived and recording the outcome of trials & errors

In fine, it is expected that when all these questions are duly answered, the newly derived formula is field tested and it turns out to be acceptable through trials & errors, this would not only be an invaluable reference material for all concerned gas operators of the world in general and those in Bangladesh in particular for undertaking strategic reformative actions so far as safe, economic and efficient operational and marketing management of the gas industry is concerned.