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QUANTUM AND IMPLICATIONS OF SYSTEM LOSS IN NATURAL GAS MARKETING IN BANGLADESH: ITS CAUSES AND CURES

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ABSTRACT

The paper is intended to present the chronological findings of the research conducted over the last decade and a half on quantification of unaccounted for gas (UFG) i.e. system loss and identification of its sources within the gas marketing companies of Bangladesh in general and in Titas Gas Transmission & Distribution Company Ltd. (TGTDCL) in particular with a network of 600 km Transmission Line and 9000 km Distribution Line. TGTDCL is the largest marketing company serving about $1.1x10^6$ (1.1 million) [1] customers and delivering $900x10^6$ Cubic Meter of the country's per day gas consumption of $1242x10^6$ Cubic Meter as of October, 2005 [2].

It has vividly transpired from the study that bulk of the 20-30% distribution loss has occurred due to unauthorized and illegal use i.e. stealing of gas through meter and regulator manipulation, meter by-pass etc by fraudulent customers. This is jeopardizing safety and cost efficiency, creating environmental hazards and eating up companies' profit.

Consequently, the result of the study has to be thought provoking to take steps in reviewing gas sale contract, registration of customers, redesigning regulatory provisions, operating patterns and gas marketing accessories including strengthening vigilance. The multi-directional impact evaluation should also be of immense benefit towards alleviation of the situation in Bangladesh and in other companies and countries of the world for a sustainable development.

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1. INTRODUCTION

The issue of system loss in natural gas marketing was in prevalence since early 20th century. Though it could never be totally avoided nor it is possible to do so, recently efforts were gaining importance to control it for obvious technical, environmental, social, operational and economic reasons. In this context, the study on UFG reduction was initiated with due consideration of current global scenario so that improvement of know-how and implementation of same could be made in respect of technology, management strategy, cost efficiency and trends in order to help alleviating the situation.

Bangladesh, a developing country of South Asia is operating its own gas industry since 1959. Its current gas use of 1295.3×10^6 cubic feet (MMCFD) is expected to shoot up tremendously in coming years. As of October, 2005, this is being supplied to 1,50,9513 industries, power plants, fertilizer factories, CNG filling stations and other commercial and domestic customers as fuel and feed stock through 5 marketing companies of Petrobangla [3] viz. TGTDCL, Bakhrahad Gas Systems Ltd (BGSL), Jalalabad Gas Transmission & Distribution System Ltd., Pashchimanchal Gas Co. Ltd. (PGCL) and the CNG company Rupantarita Prakritik Gas Co. Ltd. (RPGCL). As of September, 2005, TGTDCL alone is marketing over 60% of total volume to over 1,061,676 consumers which include 451 power plants and units, 4 fertilizer factories, 3259 industrial, 8343 commercial, 12 seasonal, 88 CNG stations and 1,049,529 domestic customers. The operating pressure of its network ranges from 950/1000 psig, down to 50 psig and only 3% domestic customers are metered served with meters and the rest are billed on flat rate basis [4].

Every marketing company is computing UFG of their system considering the variables as appropriate to their system. In view of different of UFG in gas operation and marketing within TFA, an analysis of the computation procedure, identification of related variables and pertinent consequences of UFG limits were considered to be of prime importance for suggesting the steps for alleviation.

2. CURRENT UFG ACCOUNTING PROCEDURE

Conventionally, UFG is the difference between the measurement of gas input to the summation of gas out puts with a corresponding adjustment for change in total line pack and other known pipeline usages and losses for a given period. The yearwise UFG situation of different marketing companies between 2000-2001 and 2004-2005 is given in Table-1. The companies having most of the bulk consumers and affording stricter vigilance are gaining in their UFG account.

Year	TGTDCL		BGSL		JGTDS		PGCL	
	Av. UFG (Loss /Gain)	Distribution UFG (Loss /Gain)	Av. UFG (Loss /Gain)	Distribution UFG (Loss /Gain)	Av. UFG (Loss/ Gain)	Distribution UFG (Loss /Gain)	Av. UFG (Loss /Gain)	Distribution UFG (Loss /Gain)
00-01	8.40%	28.30%	2.33%	9.85%	0.06%	0.26%	-3.23%	-622.73%
01-02	8.28%	27.35%	4.08%	15.07%	0.94%	8.07%	-2.44%	-240.77%
02-03	6.17%	16.61%	1.28%	4.91%	0.18%	0.67%	-1.88%	-143.71%
03-04	7.16%	18.15%	1.18%	4.02%	-0.29%	-1.05%	-0.45%	-20.28%
04-05	7.57%	18.31%	2.15%	6.85%	-0.60%	-2.15%	-0.40%	-15.19%

Table-1: Year wise UFG Loss/Gain Statement of different Marketing Companies for last 5 years

As in practice at TGTDCL, the UFG means the difference between the gas purchased net of its own operational use and the total sales to different customers. The purchase of gas net of TGTDCL's operational use is termed as "net through put" and hence the UFG is equated as follows:

- UFG = Flow in - (Flow out (sales) + own use)
- UFG = (Flow in - own use) - Total Sales
- UFG = Net Through Put (NTP) - Total Sales[8]

Due to short term variations in measurement, the accounting period is considered as one calendar month. The unit of measurement used to determine this figure can be volume at standard conditions, mass or energy. But inspite of uncertainty of measurement being the least for mass flow, UFG is expressed in terms of percentage in volume for convenience in every day calculations.

Petrobangla is also presenting statement of distribution UFG in its monthly report as contained in Table-1 and is based in the following formula.

$$\text{Distribution Loss (\%)} = \text{RAG} - \frac{(\text{Industry} + \text{Commercial} + \text{Domestic} + \text{Others})}{\text{RAGs}} \times 10$$

RAGs = Rest Available Gas for sales, RAGs = P – (E+F), P = Total Gas Purchase, E = Gas sold to Electricity, F = Gas sold to Fertilizer [2]

3. JUSTIFICATION OF UFG CALCUATION CONCEPTS

TGTDCL is supplying over 60% of total gas to different fertilizer & power stations and the rest to the non-bulk customers. The year wise total gas connection given during last 10 years is shown in Figure-1.

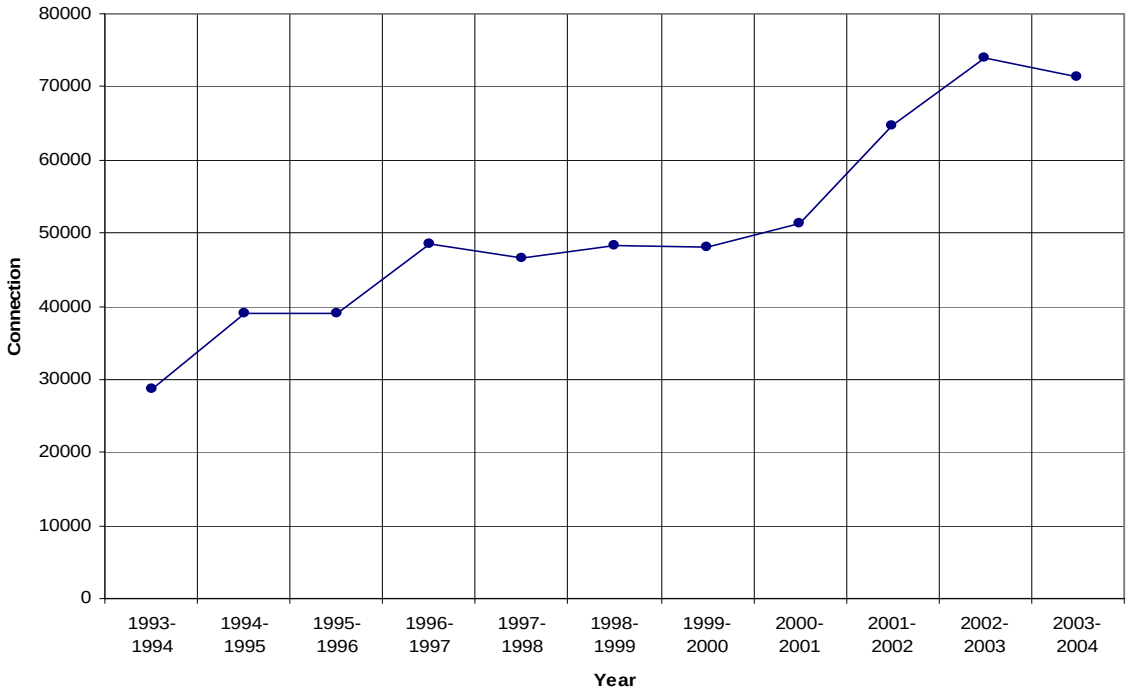

Figure-1: TGTDCL's Year Wise Number of Gas Connection During Last 10 Years

System loss in bulk customer is about ± 2%. So, except for technical losses the total UFG is responsible mostly for non-bulk customers. Because of huge bulk customer consumption, the total system loss as calculated by above formula changes with change of bulk consumption, so above concept for calculating system loss can not be justified to be a practical one. Further research work may consider all possible and applicable parameters in a practical manner.

The UFG related references as available since 1919, has described numerous factors. Still standing worthy for UFG computation.

4. RESEARCH ISSUES UNDER TAKEN BY TGTDCL

The overall System loss in of the marketing companies during 1993-94 to 2004-05 and its comparison with the non-bulk distribution loss has been shown in Figure-2. The research issues undertaken by TGTDCL are discussed below:

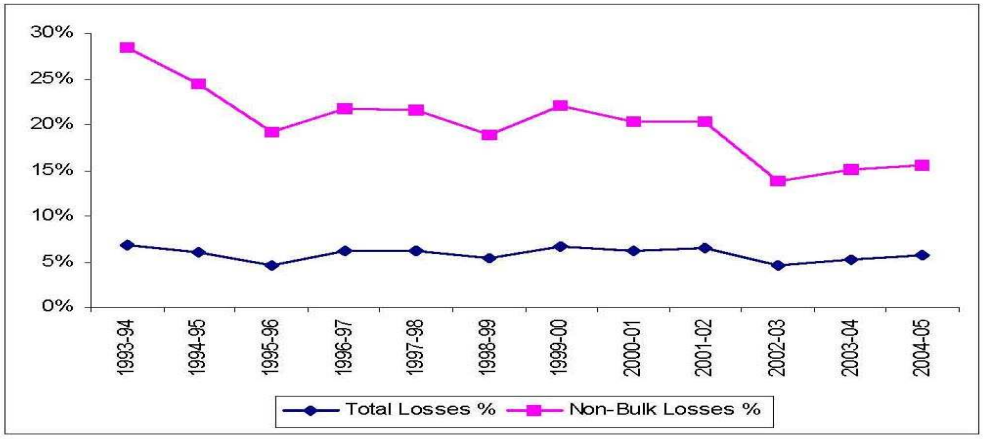

Figure-2: Overall system loss in comparison to Non-bulk losses.

4.1 UFG Accounting Formula: TGTDCL has taken note of the related literatures including AGA report 1950, AGA Task force report 1959[5] and Shell Report 1993 etc. However, the GASCOR formula of 1997 [6] for computing UFG has been found more relevant and is given as follows:

UFG = Flow in- (Flow out + Gas used / vented / lost ± change in line pack).

Most of these factors have been considered 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.

4.2 Field Survey: TGTDCL Action Program of 2001 stipulated 1.25% technical loss [7]. Emergency call reports of 1998 & 2005 are presented at Table-4. The losses per call and summation of same over a given period for a specific number of customers represent the integrity of the system & change in the degree of surveillance too.

Description	August 1998	September 2005
Customers (Overall)	667,230	1,041,732
Call frequency:		
Maximum call/day	27	19
Min. Call/day	4	2
Average Calls/day	12.1	11
Calls by types:		
Leakage	315	248
No Gas	64	59
Low pressure	14	15
Fire/Condensate etc	14	11
Leakage classification:		
Network	16	14
Service Line (including service tee, Meter, L/W cock & Regulator, RMS, Riser etc.)	306	227
House line & others	39	116
Total:	**361**	**357**

Table 4: Comparative Emergency Call Reports of TGTDCL's Distribution Department

Non-technical losses are mostly dependent on pilferage and domestic tariff loss resulting from flat rate billing of 97% domestic consumers. TGTDCL have installed some meters in different locations on random basis to calculate actual tariff loss and are installing 60,000 more domestic meters for the new customers. Simultaneously for detection of pilferages, suspected customers' premises are being surveyed and inspected. Such survey is also conducted to standardize hourly load of different categories of customers and to rationalize their consumption pattern.

4.3 Laboratory Test

The volumetric balance affected by the condensation of higher hydrocarbons present in the gas is due to reduction in flowing gas pressure and resultant temperature drop. In taking this effect on UFG condensate was analyzed in the laboratory of Bangladesh University of Engg. & Technology. They have calculated an equivalence ratio of 1 liter of condensate = 34.287 SCF of gas on the basis of heating value and to this ratio for making the system balance. More exact approximation through analysis of gas and condensate collected from different stations when done by chromatograph to calculate the volume based equivalence ratio might be helpful to compute the system balance correctly and its affect on UFG.

4.4 Literature Review

J. M. Pickford and F. E. Vandaveer[8] quoted references of an 1959 AGA[5] operating section Task force group data which included meter errors and service leakages and stated that a temperature difference of 50℉ change volume differ ence of 1%. Future, the specific gravity difference of about 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 situated to dry will decrease the volume by 1.74%. Citing references, Thomas H. and peacock P.E. on UFG in Oct. 1919[9] stated that regular attention to proper plate size and periodic replacement of displacement meters are required to avoid excessive wear of parts and diaphragms. Also large meters are incapable of registering small flows. An elevation difference of 1000 ft. causes a change in volume of about 3 percent. Therefore negative UFG is also a possibility. A calibrated barometer provides correction factor for fluctuation of atmospheric pressure as well as of elevation are essential. Further, loss of cost of gas is not the only loss, since any loss through leakage in percentage reduces the capacity of the system by that much in addition to the net loss of 86% estimated on account of fast and slow meters. These are all issues felt still valid approximating UFG figures and its impact on any gas operating company. Shell, UK in a Study in 1993 identified UFG from the difference between total gas available from all sales and total gas accounted for as sales net interchange company use. The difference included leakage and the actual loses & discrepancies due to meter inaccuracies, variations of temperature and pressure and other variables. They considered pipeline losses up to 5% for old pipelines.

4.5 COMPARISON OF UFG SITUATION IN OTHER COUNTRIES.

UFG study by Pacific Gas and Electric, USA in 1987 revealed a loss of 1.6% of receipts and this is not far from eleven years average of 2.1% (with range 0.83% - 4.65%) mostly due to measurement inaccuracies, accounting system and theft with a small percentage of 0.15% of receipt as emission. The leakage loss estimate in terms of through put in distribution of different countries are as follows [10]:

CSIRO, Australia	0.26%
Gaz de France	0.5%
LBST ,Germany	0.68%
Japan Government Figures	0.28%
Gasunie , Netherlands	0.4%
Department of Environment, UK	0.98%
AGA, USA	0.2 - 03%

5. SOURCE IDENTIFICATION PROCEDURE

5.1 Categories of UFG:

UFG is broadly divided into 2 categories, viz: Technical loss & Non-Technical loss.

5.2 Technical Loss: A study of TGTDCL and Asian Development Bank in 1993 revealed that summation of all technical losses (TL) is about 1.25% of net through put and bears 13.355% of total UFG [10]. And this figure is currently used to calculate overall UFG of the company. Sources of different types of TL is shown in Table-2.

Description	Component wise UFG	Share of total UFG
1. Technical Loss		
A) Transmission		
Pigging, purging, testing, venting, etc.	0.003	0.032%
Line Packing	0.002	0.021%
Leakage	0.001	0.011%
Metering error at purchase point, Off-trans DRSs and Bluk RMSs	0.235	2.5 11%
Base condition variation	0.2 15	2.297%
Condensation	Q..Q~.4	0.363%
Sub-Total	0.490%	5.235%
B) Distribution		
Pigging, purging, testing, venting, etc.	0.025	0.267%
Line Packing	0.010	0.108%
Network leakage	0.100	1.068%
Service line leakage	0.025	0.267%
Customer internal line leakage	0.100	1.068%
Metering error at customer's RMSs	0.400	4.274%
Set pressure variation	0.100	1.068%
Sub-Total	**0.760%**	**8.120%**
Total 1. (A+B)	**1.250%**	**13.355%**
2. Non-Technical Loss		
A) Pilferage	6.670	71.261%
B) Other loss due to inconsistent flat rate tariff	1.440	15.384%
Total 2. (A+B)	**8.110%**	**86.645%**
Grand Total (1+2)	**9.360%**	**100%**

Table-2: Technical and Non-Technical loss

5.3 Transmission and Distribution Losses: As appears in Table-2 these losses are 5.235% & 8.120% respectively of total UFG including storage. Table-3 indicates some of such TL.

Dhaka Metropolis Network				**Regional Distribution Network**				**Emergency Control Centres**
Description		**Quantity**		**Description**		**Quantity**		**Quantity**
Type	Nos.	Stored gas	Purged gas	Project	Nos.	Stored gas	Purged gas	
Industry	10	0.246	-	Industry	25	91.48	1,288.90	
Project	45	23.75	96.10	Project	75		1,108.81	347.74
Total:		23.996	99.21	Total:		1,053.24		

Table-3: TL in Commissioning New Projects and Leakages During September, 2005 in cubic meter.

5.4 Bulk Metering Loss: This is responsible for metering in accuracies at major receiving and delivery points viz gas field off take points and in power and fertilizer plants in-take points etc.

5.5 Non- Bulk Metering Loss: This is responsible for meter in accuracies in delivery points to consumers. 'Cold Gas' (below 60^0F) measuring loss mostly applies to large non-bulk customers.

5.6 Non-Technical Loss: This is calculated from: Non Technical loss = Total UFG- (Technical loss + Tariff loss + Condensate loss). The identified sources of different categories of non-technical losses may not be limited to the ones shown in Table-2.

5.7 Pilferage Loss: This loss is 71.271% of total UFG and incurred due to thelf by customers, who manipulates meter, regulator etc and draw gas though by-pass and other illegal activities viz: unauthorized use by new connections and those by the disconnected customers, un-authorized commercial use by non-metered domestic customers, un-authorized gas appliances, under billing by suppressed meter reading and un-registered gas consumption over meter capacity. Inaccurate and slow meter reading from old meters and unauthorized higher pressure consumption through regulator manipulation are no less frequently observed. Other pilferage occurs through unauthorized extensions under shelter of status-quo orders passed by courts.

5.8 Domestic Tariff Loss: Tariff Loss is mainly due to inconsistent flat rate tariff value of non-metered domestic customers. Results of studies suggested that real use of average domestic customer during 1998-1999 was higher than that of estimated consumption considered' for fixing the latest tariff. Considering 409,366 Single and 384,848 Double burners, tariff loss was calculated to be about 1.440% as shown in Table-2.

5.9 Condensate Loss: This is currently considered in terms of heating value of liquid and varies from 0.3 to 0.5% and has been considered as 0.363% in Table-2.

6. IMPACT OF UFG

Impact of UFG is considered multi-directional and the social, economical, technical and environmental effects are more prominent. Conservation of energy and safety hazards etc are no less important. However following 5 issues are discussed at this instance:

6.1 Profitability: Profit is increased with decrease of UFG. An example for the year 1999-2000[8] revealed that total gas purchase was 235125 MMCF, sales was 216161 MMCF, technical loss was 2939.24 MMCF and Domestic tariff loss was 8911.31 MMCF. So system loss of non bulk customer was 7113.44 MMCF[9]. With average gas sales value of Tk. 112/MCF for non bulk customer, so total profit of that year has been lost by (7113.44 x 112) or 796.70 million Taka (13.27 million US$).

In a recent report of Hydro Carbon Unit of Bangladesh UFG in 2004-05 stood at 27.98×10^9 (Bcf). This is an unacceptable financial drain and waste on the gas sector of Bangladesh and its entire economy. Even at the current weighted average price of gas, this equals to US$ 39 million per anum[4].

6.2 Capacity Reduction: Loss of cost of gas is not the only loss, since any loss through leakage in percentage reduces the capacity of the system by that much in addition to the net loss estimated on account of slow meters and other reasons [7]. This issue among other consequences results in to interruption of supply particularly during the peak hours of the day and in turn causes sufferings to the customers [9].

6.3 Hazard and Safety: Most of the system loss is caused by tempering of meter/regulator, consumption through by-pass line, un-authorized connection etc. Gases with 4 -18% air by volume constitute dangerous explosive mixture. Any leakages of gas metering station and unauthorized internal line cause accumulation of gas in customer's premises and have been resulting into explosion. Several such incidents and accidents have happened with loss of lives and properties apart from UFG.

6.4 Environment: In course of illegal activities and inefficient burning of natural gas, the exhaust gas is in raw or in unburned condition. CH_4 is an environmentally unacceptable gas and so is the other obnoxious exhaust. Methane emission at different phases accounts for about 0.88%. Though natural gas is an environmentally benign fossil fuel, it is a more powerful green house gas than CO_2 and as methane eventually oxidizes in the atmosphere to form CO_2 it has a substantial global warming

potential over the years [10]. With increase of concentration of same in the atmosphere, the environmental degradations are inevitable. Further study may pinpoint the quantum of such degradation.

6.5 Social: Current evil practices of a section of delinquent and fraudulent customers in connivance with others within and outside the gas industry are not only posing the foregoing negative impacts but also enhancing criminal offences which is totally undesirable for the growth of a healthy society.

7. ALLEVIATION OF SITUATION

In the process of field, desk, laboratory and workshop based experience, studies and research to identify the factors responsible for Technical and Non-Technical losses, following procedural steps stand in prominence for the reduction of UFG:

* Select proper hourly load and operational patterns for each category of customer and monitor their compliances closely.

* Field calibrate 5-year old meters and replace 10-year old meters.

* Seal metering stations of suspected customers.

* Decentralize metering workshops and calibration facilities to check in house manipulation and prompt field actions.

* Install cabinet type Regulating & Metering Stations (RMS) in load intensive customers' premises.

* Install pressure and flow logger and ultrasonic meters for suspected customers.

* Take meter readings and simultaneous RMS inspection by competent officers.

* Install internal lines in industries above ground to check meter by-pass and kill abandoned risers permanently.

* Disconnect gas lines permanently for illegal by-pass line using customers.

* Finalize and enact Gas Act to take actions through criminalizing theft of gas and tempering with meters etc. including punishing abettors. Simultaneously pursue quicker disposal of court cases.

* Minimize pigging/purging/testing/venting/blowing/commissioning/leakage and other technical losses. Calculate /measure fugitive emissions and keep record in a proper way.

* Reduce metering error at purchase point and carry out preventive maintenance regularly.

* Isolate different transmission and distribution systems to calculate appropriate system loss.

* Install some additional meters to calculate domestic tariff loss in different categories of family in different zone/area.

* Find out volume based condensate equivalence ratio and apply properly.

* Inspect and maintain RMS & Control Stations regularly and the network with due checks for pipeline cathodic protection and leakage.

* Encourage more effective and innovative manufacturing and supply of pilfer proof metering and regulating systems,

* Enforce law strictly against whoever is involved in gas theft and introduce management

incentive system for those who are contributing positively.

* Assign specific responsibility to the respective operational and marketing management and eliminate any undesirable interference in the functioning of company management itself.

* Increase vigilance activity through task-forces for the defaulting, delinquent and fraudulent customers.

* Disconnect defaulting customers promptly to prevent accumulation of bills and taking shelter of courts with fictitious pleas and asking for status-quo/injunctions.

* Allocate explicit loss reduction targets to each company and let the respective company Boards follow up for accountability.

* Adjust any recovered revenue against pilfered gas to update the previously calculated UFG.

8. CONCLUSION

Vast majority of gas system losses in Bangladesh are of a non-technical nature, largely theft. Majority of losses, approximately 70% stem from the industrial and captive power sectors and 30% being driven by the residential and commercial sectors. So UFG reduction is the main problem to be tackled by the companies to improve their financial well being [4]. Any future plan of studying multi-directional impact of UFG may include continued contact with similar gas operating companies within Bangladesh and those in other developed and developing countries of the world in order to compare with the respective situations and the steps taken thereof for adaptation as deemed appropriate. Further, program of completing the laboratory and field tests are required for ascertaining the system balance and loss control factors of prominence for developing a numerical model under varying conditions. This will help in determining financial and economic loss of gas and safety and hazard related life and property loss as well. Study of impact on environment due to emissions is also necessary for taking steps for minimization of such impacts. Continuous search for any national, regional and international input of experiences shall always remain a welcome gesture. At a minimum, losses must be reduced below 4%, with the longer-term aim of attaining international standards of 1-2% with support from the government.

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