ESTIMATION OF DOMESTIC GAS USES, WASTAGE OF GAS AND FINANCIAL ANALYSIS.

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CANDIDATE'S DECLARATION

It is hereby declared that this project or any part of it has not been submitted elsewhere for the award of any degree or diploma.

Signature of the Candidate

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RECOMMENDATION OF THE BOARD OF EXAMINERS

The project titled **"ESTIMATION OF DOMESTIC GAS USES, WASTAGE OF GAS AND FINANCIAL ANALYSIS"** submitted by **Md. Monzurul hoque**, Roll Number-040413004(p), Session: April, 2004, has been accepted as satisfactory in partial fulfillment of the requirements for the degree of **Master of Engineering in Petroleum Engineering** on 27th April, 2010**.**

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DEDICATED TO MY BELOVED FATHER AND RESPECTED TEACHERS OF PETROLEUM ENGINEERING DEPARTMENT

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Acronyms and Abbreviations

EVC	-Electronic voltage counter
TGTDCL	-Titas gas transmission and distribution company limited
MMCM	-Million cubic meter
MMCFT	- Million cubic feet
LP	- Low pressure
HP	- High pressure
SPE	- Society of Petroleum Engineers
SCM	-Standard cubic meter
MCM	-Thousand cubic meter
TCF	- Trillion cubic feet

Abstract

Our country cannot be developed without any natural resources and energy. In our country natural gas is the primary source of energy. So proper utilization of our natural gas can play vital role and bring economic prosperity. Proper use of natural gas is the vital interface between the gas distribution companies and the end users. So, proper distribution and utilization of natural gas is the key point of our economy. The economic improvement of our country is hampered by the phenomenon called gas system loss. In all categories of gas consumption there is system loss. Especially in domestic sector where the system loss is a great suffering to the customers.

One of the remedies to reduce domestic system loss suggested by many is to introduce meters. Installation and maintenance of meter system is very expensive. Although large scale system loss is attributed to domestic sector, no clear usage data is available to support that accusation. A study to actually measure the monthly gas use in an average house hold and an estimate of wastage is essential before any decision on metering can be taken. The study finds that gas wastage in domestic sector is actually much less than generally perceived. Financial investment of metering system and possible alternate options are discussed.

CHAPTER - 1

INTRODUCTION

1.1 Background and present status

Natural Gas is the most important natural resource that is available in Bangladesh. Four gas transmission and distribution companies are supplying natural gas to different types of customers in four separate regions. Titas Gas Transmission and Distribution Company Ltd (TGTDCL) is the largest and oldest company of the country, with a franchise area extending over the greater Dhaka and Mymensingh districts, including Brahmanbaria. TGTDCL supplied around 12244.166 MMCM gas, 74% of total national consumption, to an estimated 1350187 customers in 2007-2008. TGTDCL served 1335196 domestic customers (about 98.88% of total customers) that increased at a rate of 10~12% per year for downstream and delivered 1345.43MMCM in domestic sector (about 11% of total gas supplied) in 2007-2008 (TGTDCL Annual Report, 2007-2008). There is a large pipeline network consisting high pressure pipelines, intermediate pressure pipelines and service pipelines comprising a total of 10889.76 km. The operating pressure of its network ranges from 950/1000 psig down to 50 psig and only 3% domestic customers are served with meters and the rest are billed on flat rate basis. During 2007-2008, total system loss in non bulk sales incurred was 428.23 MMCM equivalent to TK.151.32 crore. The company has been implementing different actions to reduce overall system loss to 3.38% compared to 5.34% in previous year (Petrobangla Annual Report, 2007-2008). Non bulk consumers include industries, commercial, CNG and domestic.

The general perception in public is that most of the non-bulk loss is incurred in the domestic sector, although the real culprit is the industrial theft. Actions taken in 2007-08 that reduced system loss proves this notion. The objective of the project is to estimate the actual unaccounted for domestic gas i.e. system loss and identification of its causes and cures. It is very important to have an estimate of the domestic system loss so that appropriate measures can be taken for further reduction of the non-bulk losses. A clean understanding of the financial implications of the loss and its prevention options is also required.

1.2 Objectives with specific aims and possible outcome

(a) To estimate the actual system loss in domestic sector .

(b) To conduct financial analysis of domestic gas loss and its prevention.

1.2.1 Outcome :

(a) A range of domestic gas losses under different operating condition.

(b) Realistic and meaningful measures to reduce the domestic system loss.

1.3 Outline of Methodology

(a) Conduct of Laboratory test with setting up wet test meter, gas burner and U-tube to determine gas flow under various conditions.

(b) Quantification of unaccounted gas in domestic sector.

(c) Cost of metering household gas.

(d) Comparative financial analysis of introducing meters and alternate options.

CHAPTER - 2

DOMESTIC CUSTOMER

Natural gas has diversified use. A substantial percentage of this gas is used in domestic sector for cooking purpose. In this chapter, the various types of customers according to pressure, flow rate and type of gas uses will be clarified. This chapter will also contain gas sales, gas purchases, revenue and other statistics.

2.1 Classification of gas users

Definition and characteristics of domestic customers are as follows:
This type of customers include- House/Building uses as a resident, Flat/Colonies of various Government/Semi Government/Autonomous organization and Hostel, Laboratories, Canteen, Hospital, Mess, Child home, Hermitage, Tomb, Charitable organizations. Domestic customers can be divided into two classes-

1) Domestic metered
2) Domestic un-metered.

Domestic metered customers: In Titas Gas franchise area, most of the domestic customers are un-metered and few are metered.

Domestic un-metered customers: Except some metered customers, all other domestic customers are supplied gas without meters. Gas bills are made on the flat rate basis as there are no meters for measurement of gas consumption.

Depending on the nature and objective of the gas use, customers are classified as follows-

A) Non- Bulk Customer
    (1) Domestic customer
        (i) Domestic metered
        (ii) Domestic un-metered

(2) Commercial
(3) Industrial
(4) Seasonal
(5) Tea-state
(6) CNG

B) Bulk customer
1) Power producing
2) Fertilizer
3) Captive power

In bulk sector, system loss is comparatively less but in case of domestic sector system loss is about 0.85%. In the year 2008-2009, TGTDCL supplied around 13441.76 MMCM gas for all categories of customers and 1461.94 MMCM for domestic customers only. On the other hand TGTDCL supplied 1345.43 MMCM for domestic customers in 2007-08. So gas use in domestic sector is increased by 8.66% in FY 2008-09. In Table 2.1 gas consumption in different sectors are shown in bellow:

Table 2.1 Category wise gas consumption (2008-2009)

Category of customers	Actual purchase		Actual sales	
	(MMCM)	(Tk.crore)	(MMCM)	(Tk.crore)
Power	5552.15	1112.21	5551.85	1490.02
Fertilizer	1015.07	168.93	1005.82	225.38
Industrial	2442.17	870.41	2421.62	1268.38
CNG	604.70	491.98	599.76	604.15
Commercial	106.48	77.37	135.36	113.22
Domestic	1474.46	482.60	1461.94	698.15
Captive	2284.43	578.76	2265.41	830.97
Total	13479.46	3783.24	13441.76	5230.27

Category wise gas consumption (2008-2009) as shown in Table 2.1 is given in the form of pie chart in Figure 2.1

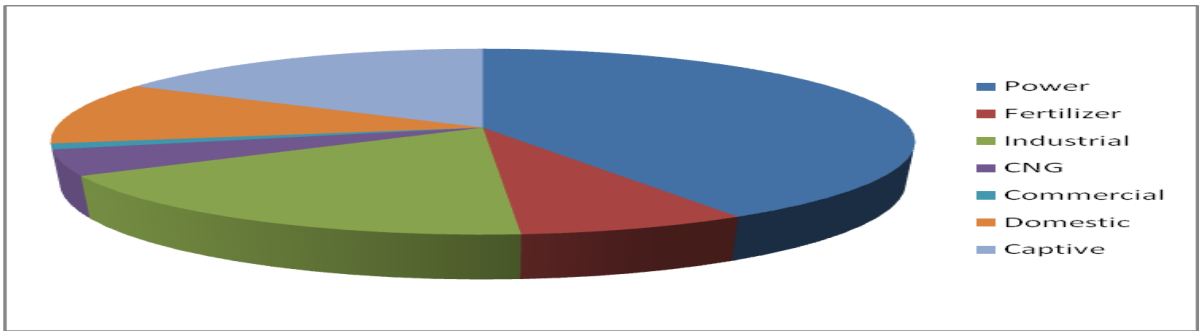

Figure 2.1 Customer category wise gas consumption in pie chart.

2.2 Gas customers in Titas Gas franchise areas

TGTDCL franchise area includes greater Dhaka, greater Mymensingh and Brahmanbria shown in Appendix-A (Figure A1). It supplies gas to different types of customers in those areas. Table 2.2 shows the numbers of customers handled by TGTDCL in different categories. Domestic customers were 1335196 in 2007-2008 and 1483300 in 2008-2009. It is seen that domestic customers increased by 11% in FY 2008-2009.

Table 2.2 Gas Customer Status of TGTDCL (Annual report 2009, TGTDCL)

Category of customers	Total No of customers as on 31Dec, 2009
Power(PDB)	11
Power(Pvt)	20
Fertilizer	04
Industrial	4545
CNG	317
Commercial	10805
Seasonal	12
Domestic Unmetered	1483300
Captive	1023
Total	1500038

Table 2.2 shows that TGTDCL handles a large number of domestic customers which is 98.8% of its total number of customers. Category wise gas customers status (2008-2009) of TGTDCL as shown in Table 2.2 is given in the form of bar chart in Figure 2.2

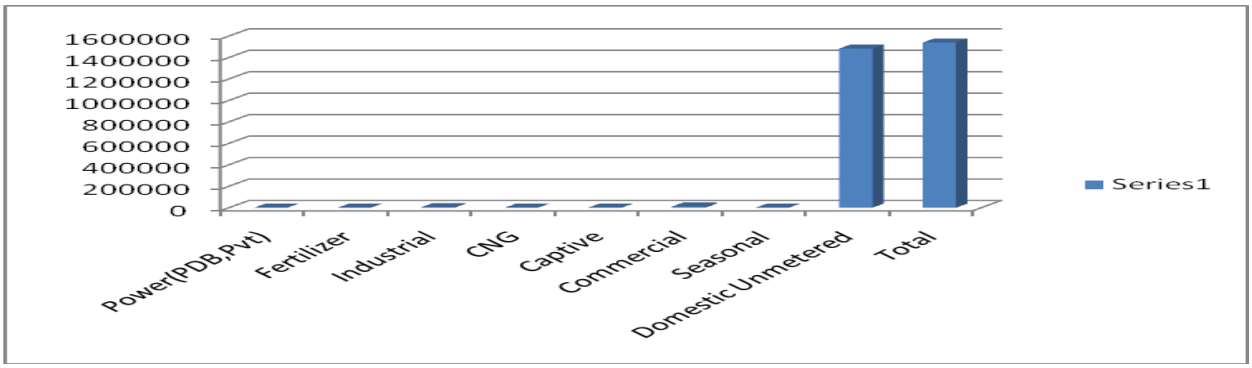

Figure 2.2 Gas Customer Status of TGTDCL (2008-2009)

2.3 Slab of tariff rates for different customers

For different category of customers tariff rates are different and in case of bulk customers tariff rate is comparatively less. Table 2.3 shows the previous and present tariff rates of different customers.

Table 2.3 Category wise tariff rate

Types of customer			Tariff rate(Tk/ m3) Before 1st Feb, 2010	Tariff rate(Tk/ m3) From 1st Feb, 2010
A. Non Bulk Customer	1. Domestic	a. Domestic metered	4.59	5.16
		b. Domestic un-metered	Double Burner Tk 400/month	Double Burner Tk 450/month
			Single Burner Tk 350/month	Single Burner Tk 400/month
	2. Commercial		8.23	9.47
	3. Industrial		5.23	5.86
	4. CNG		2.47	9.97
B. Bulk customer	5. Power producing customer.		2.61	2.82
	6. Fertilizer producing		2.24	2.58
	7. Captive power producing		3.73	4.18

CHAPTER - 3

GAS MEASURING DEVICES AND CALIBRATIONS

Measurement of Natural gas is always conducted on a flowing stream. Accountable metering is very important because of registered volume used for billing purposes. In this chapter, meter types, calibration of meters will be discussed. Especially wet-test flow metering system will be focused.

3.1 Classification of gas flow meters

A basic distinction is generally drawn between velocity meters and volumetric and positive displacement meters. Over all classification of meters are shown as follows:

i. Differential pressure measurement ----------Orifice, Venturi and Nozzle meter.
ii. Positive displacement---------- Diaphragm meter, wet-test flow
iii. Rotary inferential ----------Rotary meter, Turbine meter.
iv. Fluid oscillatory ----------Vortex, Shedding, Swirl meter.
v. Electromagnetic ----------Magnetic flow meter
vi. Ultrasonic ----------Doppler flow meter.
vii. Direct mass ----------Coriolis
viii. Thermal ----------Thermal profile.

At present orifice and turbine meters are most widely used for bulk customers gas measurements and purposes of input measuring. Diaphragm meters are commonly used for commercial and domestic customers which requires small quantity of gas at low operating pressure.

3.2 Selecting parameters

Meter selection varies for available space for the installation of such meters (For example, the number of pipe straight lengths required in upstream and downstream of the meter), the economic consequence of uncertainties in the measurement (Expectation of the customer as to the accuracy of the fluid measurement), the legal metrology requirements (Ease of calibration etc), whether the meter is cost effective. Table -3.1 shows the ranges of measuring pressures and flow rates of different meters.

Table 3.1 : Selecting Meters

Application	Metering pressure(Kpa)	Flow m^3/h	Suggested Meter Type	Basic auxiliary Devices
Domestic customer	1.75	0 to 2	LP diaphragm	None
Commercial/ Industrial customer	1.75 34.5 to 138 1.75 to 413 1.75 to 413	12 to 40 12 to 40 40 to 450 450	LP diaphragm LP diaphragm Rotary Turbine	None PFM or EVC EVC EVC
FTU master meter	413 to 2400 2400 and up	0 to 700 0 to 700	HP diaphragm Rotary	EVC EVC
HP sales/ Purchase station	690 and up 690 and up	700 and up 700 and up	Turbine Orifice	EVC EVC
Well production	690 and up		Orifice	EVC

In case of domestic measurement we have taken LP diaphragm type (wet-test gas flow meter)

3.3 Calibration procedure of Wet-test flow meter

Precision Wet-Test Gas Flow Meters
LP diaphragm Drum-Type **Series: TG**

Figure 3.1 Wet-test gas flow meter

Measurement Principle

Wet-test gas meters function upon the principle of positive displacement. The sample gas stream rotates a measuring drum within a packing fluid, usually water or low viscous "white" (clear) oil.

A needle-dial and counting mechanism, coupled to the rotating drum, records the volume of gas flow as it sequentially fills and empties from the drum's rigid, fixed volume measuring chambers.

Measuring Ranges

Wet-test gas meters offer seven standard measuring ranges from as low as one l/hr up to 18,000 l/hr.

Accuracy

±0.20% or better.

User Benefits

Applications and User Benefits

Wet-test (drum-type) gas flow meters are used universally to measure and record gas volume and gas flow rate for many industrial, petroleum and chemical processes; environmental; pilot plant or test; controlled chamber; laboratory and research applications. Wet-test meters consistently provide the highest accuracy and precision even at the lowest gas flows with inert or the most aggressive gases. A wet-test flow meter following features-

- Most durable construction available
- Use with inert and corrosive gases
- Highest accuracy
- Laboratory precision
- Largest selection of measuring ranges
- Computer monitoring
- Real-Time electronic display
- No maintenance

3.4 Laboratory Study of flow rate for double and single burner at various pressures

The study will depict real gas consumption at various pressures in case of both single and double burners with the help of wet-test flow meter. From the calculated gas consumption rate, actual system loss of gas in domestic sector comparing with monthly tariff based rate (rate fixed by TGTDCL) and test sample rate conducted by gas load calculation committee will be determined.

The test was carried out in BUET Petroleum and Mineral Resources Engineering Department lab and its experimental set up is shown in Appendix-B (Figure B1). At the beginning of our study, the valve attached with gas supply line was opened fully and gas flow pressure and its temperature were measured with the help of manometer and thermometer which was 14 cm water height (0.192 psig) and 86º F respectively. Then at different openings (rotating the attached valve gradually) of the burner different amount of gas flow rates were measured with the help of wet-test flow meter and their consequent differential pressures and the results are shown in tables and graphs in Appendix-C (Table C1-C6, Figure C1-C6). We started our study at 06.30 am and ended at 22.30 pm for the duration of 16 hours for three consecutive days. In different period of the day for two hours duration differential pressures for both double burner (at full opening) and single burner (at minimum opening) were measured (in cm water height) with the help of manometer (U-tube) and corresponding flow was measured by the Wet-test flow meter. In our calculation of gas consumption in domestic sector, we assumed that all the burners (double burners) were kept at full opening and in case of loss calculation; we considered that all burners were single and were kept at minimum opening. Table 3.2 shows various differential pressures and their corresponding gas flow in different times of the day.

Table 3.2 Experimental data

Time period (hrs)	Differential pressure for double burner in cm water height	Differential pressure for single burner in cm water height	Gas consumption for double burner m3	Gas consumption for single burner (at minimum opening) m3
06.30-08.30	6.8	10	0.712	0.068
08.0-10.30	7.2	11.2	0.716	0.067
10.30-12.30	6.6	9.8	0.708	0.066
12.30-14.30	7	10	0.716	0.068
14.30-16.30	7.2	12	0.724	0.069
16.30-18.30	7	11.2	0.720	0.0685
18.30-20.30	7.2	11	0.720	0.0685
20.30-22.30	6.6	10	0.712	0.068

The arithmetic average flow rate for double burner (full opening)

=(0.712+0.716+0.708+0.716+0.724+0.720+0.720+0.712)/16

=5.728/16=0.358 m3/hr

The arithmetic average flow rate for singe burner (at minimum opening)

=(0.068+0.067+0.066+0.068+0.069+0.0685+0.0685+0.068)/16

=1.088/16=0.068 m3/hr

3.5 Basis of calculation of gas consumption in domestic sector

Basis (pressure, temperature, number of hours per day, flow rate) of calculation to determine actual gas uses and loss in domestic sector are considered as shown in Table 3.3.

Table 3.3 Basis of calculation of gas consumption in domestic sector for double burners and single burner

	Experimental data		As per Regulation 2004		As per monthly tariff	
	Double burner	Single burner	Double burner	Single burner	Double burner	Single burner
Pressure (psig)	0.192		0.28	0.28		
Flow rate (m3/hr) (Full open)	0.358	0.223	0.595	0.339	0.363	0.258
Number of hrs/day	8	10	8	10	8	10
Minimum Flow rate (m3/hr)	0.132	0.068		0.099		
Gas Temp	86 F		85 F			
Material of gas burner	M.S steel		M.S steel			
Burner ignition system	Manual		Manual			

The flow rates as per monthly tariff for double and single burner shown in Table 3.3 are calculated on the basis of the tariff of Tk. 450/month and Tk. 400/month respectively. For the gas uses of double burner for 8 hrs per day at Tk. 5.16/m3, the flow rate is {450/(5.16*8*30)} 0.363 m3/hr and for single burner the hrs of operation is used as 10 hrs/day and the flow rate 0.258 m3/hr.

Titas along with other Transmission and Distribution Companies formulated gas flow rates under a regulation in 2004 which set a higher gas pressure at burner tip and as a result, the flow rates are also high.

3.6 Gas load committee's observation

Gas load calculation committee (formed in 24-10-2005 with office order no. 21.37.51/385) have calculated the amount of monthly gas consumptions of domestic customers in double burners of different areas in Dhaka city and a double burner domestic customer was found using 98.57 m3 per month on an average. In Dhaka city some meter readings are nearly close to our practical laboratory test result and some are varying from our study result. Table 3.4 shows monthly gas consumption for double burners in domestic sector of different areas in Dhaka city.

Table 3.4 Gas meter reading of domestic customer determined by Titas gas load committee in Dhaka City

Sl. No	Customer Code	Number of Double burner	Amount of used gas (m3/month)
1	1302649	1	74.59
2	1302650	1	83.73
3	1302782	1	111.06
4	1302646	1	77.63
5	1302645	1	133.47
6	1302451	1	84.53
7	1302310	1	114.12
8	1302326	1	89.65
9	1302327	1	93.92
10	1302625	1	82.69
11	1302664	1	72.45
12	1302669	1	115.27
13	1302666	1	95.1
14	1302671	1	84.53
15	1302156	1	93.92
16	1302158	1	197.6
17	1302160	1	91.66
18	1302161	1	105.66
19	1302740	1	90.57
20	1302755	1	107.45
21	1302535	1	70.44
		Average	98.57

Gas load calculation committee also have calculated seasonal variation of gas consumption of different Titas franchise areas in domestic sector and shows that gas consumption varies season to season and region to region. In winter season (November to January) gas consumption is higher than other seasons. Table 3.5 shows the variation of gas consumption from season to seasons and region to regions.

Table 3.5 Determination of seasonal effect in monthly gas consumption in different Titas gas Franchise area:

Area	Number of Single burner	Number of Double burner	Total	Month	Gas used SCM	Monthly average SCM
Mymenshing	7127	11239	18366	Jul-05	1550566	84.43
	7108	11416	18524	Aug-05	1577351	85.15
	7084	11546	18630	Sep-05	1551070	83.26
	7044	11651	18695	Oct-05	1694236	90.63
	6190	12531	18721	Nov-05	1694236	88.04
Jamalpur	1826	1986	3812	Jul-05	317404	83.26
	1815	2006	3821	Aug-05	303883	83.26
	1810	2323	4133	Sep-05	352302	79.53
	1805	2339	4144	Nov-05	339497	81.92
	1800	2356	4156	Dec-05	398871	95.97
Sharpur	765	1142	1907	Jul-05	160803	84.32
	756	1332	2088	Sep-05	158686	76
	743	1465	2208	Nov-05	158686	78.91
Kishorgong	1930	2556	4486	Jul-06	452031	100.76
	1914	2937	4851	Nov-06	499843	103.04
Netrokona	1026	1758	2784	Jul-06	267525	96.09
	913	1759	2672	Sep-05	245859	92.01
	911	1909	2820	Nov-05	272541	96.65
Goforgau	235	665	900	Jul-05	84395	93.77
	227	672	899	Jun-05	87463	97.29
B-baria		108	108	Jul-05	10747.32	99.51
Ashugong		980	990	Jul-05	128319.77	129.62
		980	990	Dec-05	120055.01	121.27
Savar		16	16	Nov-05	2156.39	134.77
		16	16	Dec-05	2889.27	180.58

From the table above it is seen that the effect of variation of gas consumption from season to seasons is not significant but regional variation is a bit significant due to the variation of gas line pressure. The usage in Savar area is unusually high. First of all this sample size was small (16) and all of them had multifamily use. As a result the gas consumption seem to be much higher than average.

Observation result of titas gas load calculation committee for unmetered domestic customers around Titas franchise areas are summarized here. These results are arithmetic average for monthly gas consumption.

- In Dhaka city
  - i) Gulshan/Banani
    Double burner =98.57 SCM
  - ii) Jinjira Area
    Double burner =101.96 SCM
- Out side Dhaka
  - i) Mymenshing Area
    Double burner =81.40 SCM
  - ii) Bhrammonbaria
    Double burner =99.51 SCM
  - iii) Ashugong
    Double burner =129.62 SCM
  - iv) Savar
    Double burner =134.77 SCM

The average gas consumption of different region can be taken in order to calculate the amount of gas consumption by gas load calculation committee.

The average monthly gas consumption of Titas franchise is

{(98.57+101.96+81.40+99.51+129.62+134.77)/6} 107.63 m3

Although gas load committee used these number, the data from Savar and Ashugong should have been excluded. The monthly average without Savar and Ashugong data is

{8.57+101.96+81.40+99.51)/4} 95.36 m3

The monthly gas consumption rate as per Regulation 2004 and the average monthly gas consumption of titas franchise area are taken in our calculation shown in Chapter 4.

CHAPTER - 4

ESTIMATION OF THE ACTUAL GAS USES AND WASTAGE OF GAS IN DOMESTIC SECTOR

Considering different number of gas consumption hours per day of full opening and low opening for both single and double burner, amount of yearly gas consumption will be determined and thereby comparing it with un-metered flat rate, actual gas uses and system loss will be determined.

4.1 Gas consumption as per Gas distribution Regulation 2004

As per gas distribution regulation 2004, gas load at 0.28 psig or 8 inch or 20.32 cm water height for a domestic double burner was 21 cft / hr (0.595 m^3/hr) at full opening and 3.5 cft/hr (.099 m^3/hr) at a very low opening and for a single burner it was 12 cft/hr (0.339 m^3/hr) at full opening. An operational pattern of 8 hours/ day and 10 hours/day are included in Gas Sales Contract for domestic double burner and single burner customers. On the basis of 8 hours for double burner and 10 hours for single burner at full opening, considering diversity factor 0.8 and total number of domestic customer of 1.335 million, the following calculation is made in regard to measure gas uses.

If a domestic double burner is kept full open for 8 hrs/day on an average, then, monthly load = 21x8x30x0.8/35.3147 m^3 = 114.17 m^3

= 1370.04 m^3/year

=1370.08*1.335 =1829.00 MMCM (for total customers)

If a domestic single burner is kept full open for 10 hrs/day on an average, then, monthly load =12*10*30*0.8/35.3147 = 81.55 m3

= 978.63 m^3/year

=978.63*1.335 =1306.47 MMCM (for total customers)

4.2 Gas consumption based on sample test by the gas load calculation committee

If a domestic double burner is kept full open for 8 hrs/day on an average, then its monthly average gas consumption = 107.63 m^3 (Section 3.6)
= 1291.56 m^3/year
=1291.56*1.335 =1724.23 MMCM (for total customers)

4.3 Gas consumption based on monthly tariff

A domestic customer using double burner is charged Tk. 450/month. On the other hand, domestic metered customers are billed at the rate of Tk. 5.16 / m3. So Tk. 450 is accounted for the amount of 450/5.16 m^3 gas or, 87.21 m^3 and a domestic customer using single burner is charged Tk. 350/month. So Tk. 400 is accounted for the amount of 400/5.16 m^3 or 77.52 m^3
So if a domestic double burner is kept full open for 8 hrs/day on an average, then its monthly gas consumption = 87.21 m^3
=1046.52 m^3/year
=1046.52*1.335 =1397.104 MMCM (for total customers)
And if a domestic single burner is kept full open for 10 hrs/day on an average, then its monthly gas consumption = 77.52 m3
=930.24 m^3/year
=930.24*1.335 =1241.870 MMCM (for total customers)

4.4 Actual gas consumption based on practical study

Practical tests were conducted at petroleum and mineral resource Lab at 0.192 psig or 14 cm water height for a domestic double burner and a single burner by wet-test flow meter were 0.358 m^3/hr and 0.213 m^3/hr respectively at full opening. At very low opening (Below which the flame extinguishes) domestic gas flow were 0.068 m3/hr and 0.132 m3/hr respectively for a single burner and double burner. Based on the above experiment, following calculations are made:

If a domestic double burner is kept full open for 8 hrs/day on an average then, monthly load = 0.358x8x30 m^3= 85.92 m^3= 1031.04 m^3/year.
Now total number of domestic customer is 1.335 million. So yearly total gas consumption in domestic sector = 1031.04*1.335 =1376.44 MMCM

If a domestic single burner is kept full open for 10 hrs/day on an average, then, monthly load =0.223*10*30=66.9 m3

=802.8 m^3/year

=802.8*1.335 =1071.74 MMCM (for total customers)

From the different gas consumption rates, it is seen that monthly gas consumption for a double burner based on tariff and based on our study are nearly equal to each other and gas consumption according to Distribution Regulation 2004 and gas load committee are much more higher than the real consumption. Table 4.1 shows different gas consumption rates.

Table 4.1 Comparison of different study for monthly gas consumption

SCM/month	Distribution regulation 2004	Gas load committee	Tariff based rate	Practical study
Double burner	114.17	107.63	87.21	85.92
Single burner	81.55	97.6	77.52	66.9

4.5 Actual loss

Domestic customers normally keep their burners at very low opening after cooking their food. Now we are calculating amount of gas loss due to keeping burners at minimum opening for 4 and 6 hours per day.

If a single burner is kept at very low opening for 4 hrs/day then monthly gas consumption =0.068*4*30 = 8.16 m3

= 97.92 m^3/year

=97.92*1.335=130.72 MMCM (for total customers)

If a single burner is kept at very low opening for 6 hrs/day then monthly gas consumption =0.068*6*30 = 12.24 m3

=146.88 m^3/year

=146.88*1.335=196.08 MMCM (for total customers)

Again, if a double burner is kept at very low opening for 4 hrs/day then monthly gas consumption =0.135*4*30

=16.2 m3

=194.4 m^3/year

=194.4*1.335=259.52 MMCM (for total customers)

If a double burner is kept at very low opening for 6 hrs/day then monthly gas consumption =0.135*6*30

=24.3 m3

=291.6 m^3/year

=291.6*1.335=389.28 MMCM (for total customers)

Generally on an average we can consider that a domestic customer keeps one burner at low opening for 4 hours per day and in this case annual gas loss in domestic sector as a whole is 130.72 MMCM (4616.34 MMCFT).

CHAPTER - 5

FINANCIAL ANALYSIS OF DOMESTIC GAS USES

Two aspects of a project are technical and financial feasibilities. If a project is found technically sound, then it is necessary to evaluate its soundness from financial point of view. Financial analysis of a project is concerned about profitability analysis, efficiency analysis, effectiveness analysis, cost effectiveness analysis and sustainability analysis (Ross S.A. Westerfield R.W. and Jordan B.D. 2003).

5.1 Determination of gas consumption and revenue loss in domestic sector

In order to conduct financial analysis, yearly gas consumption for double burners at different numbers of hours per day at the different percentages of customers are shown in Table 5.1 (based on experimental data) as per our study and yearly gas consumption of different percentage of customers due to monthly tariff based in Table 5.2.

Table 5.1 Determination of yearly gas consumption for double burners

Hrs of use/ day	monthly consumption m3/customer	Yearly consumption in MMCM for total customers							
		100%	20%	30%	40%	50%	60%	70%	80%
10	107.4	1720.800	344.16	516.24	688.32	860.4	1032.5	1204.56	1376.64
9	96.66	1548.720	309.74	464.62	619.48	774.36	929.23	1084.10	1238.97
8	85.92	1376.640	275.32	412.99	550.65	688.32	825.98	963.648	1101.31
7	75.18	1204.560	240.91	361.37	481.82	602.28	722.74	843.192	963.64
6	64.44	1032.480	206.49	309.74	412.99	516.24	619.49	722.736	825.98
5	53.7	860.400	172.08	258.12	344.16	430.2	516.24	602.280	688.32
4	42.96	688.320	137.66	206.5	275.32	344.16	412.99	481.824	550.65
3	32.22	516.240	103.24	154.87	206.49	258.12	309.74	361.368	412.99
2	21.48	344.160	68.83	103.25	137.66	172.08	206.5	240.912	275.32

Table 5.2 Determination of yearly gas consumption for double burners

Monthly gas consumption m3/customer (8 hrs use/day)	Yearly consumption in MMCM	20%	30%	40%	50%	60%	70%	80%
87.16	1396.50	279.30	418.95	558.60	698.25	837.9	977.6	1117.2

Generally, certain percentage of customers keep their burners at low opening without cooking or heating anything and due to this, Government loses certain amount of revenue per year. Yearly revenue loss for excess gas consumption at different numbers of hours per day for different percentages of customers is shown in Table 5.3.

Table 5.3 Determination of yearly revenue loss from excess gas consumption

Hrs of use/day	Yearly total gas loss at low opening m3 (For a single customer)	Yearly total gas loss MMCM (For total customers)	TK. in million (For 100% of total customers)	TK. in million (For 75% of total customers)	TK. in million (For 50% of total customers)
2	48.96	65.37	337.3154	252.9865	168.6577
4	97.92	130.74	674.6307	505.9731	337.3154
6	146.88	196.11	1011.946	758.9596	505.9731
8	195.84	261.48	1200.215	900.1614	600.1076

5.2 Mitigation of revenue loss

In order to mitigate the revenue loss for excess use of gas in domestic sector pre-paid meter can be an alternative. We will verify whether it will be economically viable or not. Total investment cost for 1.335 million domestic customers will be taken in our calculation.

Investment cost analysis

	(million)
A. Fixed cost :	
1.Meter price @ $80/meter CIF value	$106.80
2. Pipe line and accessories	$16.02
3. Installation	$16.02
4. Server and POS terminal equipment with sgms	$1.81
5. POS Office set up	$1.14
6. IC card cost	$0.53
7. Vehicle	$6.68
8. Training of Titas personals	$0.33
Total	**$149.33**
B. Operational cost: (per year)	
1. Services and maintenance	$2.99
2.Utility expenses	$0.27
3. Rent	$0.27
4. Salaries and wages	$5.34
5. Administrative overhead	$1.34
Total	**$10.20**
C. Cash inflow	**$9.64**

The above data of both fixed cost and operational cost are taken from the project report prepared by Sarwar, Golam (2007). Data of Cash inflow are taken from Table 5.3 for 4 hrs use of gas per day.

Here total fixed cost for 1.335 million domestic customers for metering system is $149.33 million. Total operational cost for 1.335 million domestic customers for metering system is $10.20 million. Again total loss from all domestic wastage of gas for 4 hrs/day was calculated as $ 9.64 million. It is seen that in order to mitigate the loss of $ 9.64 million, the initial cost and the yearly operational cost do not justify establishing pre-paid meters in the households.

Considering a project period of 20 years with 2% increase in operational cost and 8% increase in cash inflow per year, the net present value (NPV) of the project at different discount rates with

different numbers of hours of gas use per day at different conditions are shown in Tables 5.4, 5.5 and 5.6.

Table 5.4 NPV at minimum flow using 4 hrs per day (for single burner)

Year	Total out flow	Net Cash in flow	Net cash flow	present value at various discount rate					
				10%		15%		25%	
				Present worth factor	Present value	Present worth factor	Present value	Present worth factor	Present value
0	-$149.33	$0.00	-$149.33	1.000	-$149.33	1.000	-$149.33	1.000	-$149.33
1	-$10.20	$9.64	-$0.56	0.909	-$0.51	0.870	-$0.49	0.800	-$0.45
2	-$10.40	$10.41	$0.01	0.826	$0.01	0.756	$0.01	0.640	$0.00
3	-$10.61	$11.03	$0.42	0.751	$0.32	0.658	$0.28	0.512	$0.22
4	-$10.82	$11.69	$0.87	0.683	$0.60	0.572	$0.50	0.410	$0.36
5	-$11.04	$12.39	$1.36	0.621	$0.84	0.497	$0.68	0.328	$0.45
6	-$11.26	$13.14	$1.88	0.564	$1.06	0.432	$0.81	0.262	$0.49
7	-$11.48	$13.93	$2.44	0.513	$1.25	0.376	$0.92	0.210	$0.51
8	-$11.71	$14.76	$3.05	0.467	$1.42	0.327	$1.00	0.168	$0.51
9	-$11.95	$15.65	$3.70	0.424	$1.57	0.284	$1.05	0.134	$0.50
10	-$12.18	$16.59	$4.40	0.386	$1.70	0.247	$1.09	0.107	$0.47
11	-$12.43	$17.58	$5.15	0.350	$1.81	0.215	$1.11	0.086	$0.44
12	-$12.68	$18.64	$5.96	0.319	$1.90	0.187	$1.11	0.069	$0.41
13	-$12.93	$19.76	$6.82	0.290	$1.98	0.163	$1.11	0.055	$0.38
14	-$13.19	$20.94	$7.75	0.263	$2.04	0.141	$1.10	0.044	$0.34
15	-$13.45	$22.20	$8.74	0.239	$2.09	0.123	$1.07	0.035	$0.31
16	-$13.72	$23.53	$9.81	0.218	$2.13	0.107	$1.05	0.028	$0.28
17	-$14.00	$24.94	$10.94	0.198	$2.17	0.093	$1.02	0.023	$0.25
18	-$14.28	$26.44	$12.16	0.180	$2.19	0.081	$0.98	0.018	$0.22
19	-$14.56	$28.02	$13.46	0.164	$2.20	0.070	$0.95	0.014	$0.19
20	-$14.85	$29.70	$14.85	0.149	$2.21	0.061	$0.91	0.012	$0.17
		NPV			**-$120.36**		**-$133.09**		**-$143.29**

Table 5.5 NPV at minimum flow using 8 hrs per day (for single burner)

Year	Total out flow	Net Cash in flow	Net cash flow	present valu at various discount rate					
				10%		15%		25%	
				Present worth factor	Present value	Present worth factor	Present value	Present worth factor	Present value
0	-$149.33	$0.00	-$149.33	1.000	-$149.33	1.000	-$149.33	1.000	-$149.33
1	-$10.20	$19.27	$9.08	0.909	$8.25	0.870	$7.89	0.800	$7.26
2	-$10.40	$20.81	$10.41	0.826	$8.61	0.756	$7.87	0.640	$6.66
3	-$10.61	$22.06	$11.45	0.751	$8.61	0.658	$7.53	0.512	$5.86
4	-$10.82	$23.39	$12.57	0.683	$8.58	0.572	$7.18	0.410	$5.15
5	-$11.04	$24.79	$13.75	0.621	$8.54	0.497	$6.84	0.328	$4.51
6	-$11.26	$26.28	$15.02	0.564	$8.48	0.432	$6.49	0.262	$3.94
7	-$11.48	$27.85	$16.37	0.513	$8.40	0.376	$6.15	0.210	$3.43
8	-$11.71	$29.52	$17.81	0.467	$8.31	0.327	$5.82	0.168	$2.99
9	-$11.95	$31.30	$19.35	0.424	$8.21	0.284	$5.50	0.134	$2.60
10	-$12.18	$33.17	$20.99	0.386	$8.09	0.247	$5.19	0.107	$2.25
11	-$12.43	$35.16	$22.74	0.350	$7.97	0.215	$4.89	0.086	$1.95
12	-$12.68	$37.27	$24.60	0.319	$7.84	0.187	$4.60	0.069	$1.69
13	-$12.93	$39.51	$26.58	0.290	$7.70	0.163	$4.32	0.055	$1.46
14	-$13.19	$41.88	$28.69	0.263	$7.56	0.141	$4.05	0.044	$1.26
15	-$13.45	$44.39	$30.94	0.239	$7.41	0.123	$3.80	0.035	$1.09
16	-$13.72	$47.06	$33.34	0.218	$7.25	0.107	$3.56	0.028	$0.94
17	-$14.00	$49.88	$35.88	0.198	$7.10	0.093	$3.33	0.023	$0.81
18	-$14.28	$52.87	$38.60	0.180	$6.94	0.081	$3.12	0.018	$0.70
19	-$14.56	$56.05	$41.48	0.164	$6.78	0.070	$2.91	0.014	$0.60
20	-$14.85	$57.17	$42.31	0.149	$6.29	0.061	$2.59	0.012	$0.49
		NPV			**$7.58**		**-$45.67**		**-$93.70**

Table 5.6 NPV at minimum flow using 2 hrs and maximum flow using another 2 hrs per day

Year	Total out flow	Net Cash in flow	Net cash flow	present valu at various discount rate					
				10%		15%		25%	
				Present worth factor	Present value	Present worth factor	Present value	Present worth factor	Present value
0	-$149.33	$0.00	-$149.33	1.000	-$149.33	1.000	-$149.33	1.000	-$149.33
1	-$10.20	$30.19	$19.99	0.909	$18.17	0.870	$17.38	0.800	$15.99
2	-$10.40	$32.60	$22.20	0.826	$18.35	0.756	$16.79	0.640	$14.21
3	-$10.61	$35.21	$24.60	0.751	$18.49	0.658	$16.18	0.512	$12.60
4	-$10.82	$38.03	$27.21	0.683	$18.58	0.572	$15.56	0.410	$11.14
5	-$11.04	$41.07	$30.03	0.621	$18.65	0.497	$14.93	0.328	$9.84
6	-$11.26	$44.36	$33.10	0.564	$18.68	0.432	$14.31	0.262	$8.68
7	-$11.48	$47.90	$36.42	0.513	$18.69	0.376	$13.69	0.210	$7.64
8	-$11.71	$51.74	$40.03	0.467	$18.67	0.327	$13.08	0.168	$6.72
9	-$11.95	$55.88	$43.93	0.424	$18.63	0.284	$12.49	0.134	$5.90
10	-$12.18	$60.35	$48.16	0.386	$18.57	0.247	$11.90	0.107	$5.17
11	-$12.43	$65.17	$52.75	0.350	$18.49	0.215	$11.34	0.086	$4.53
12	-$12.68	$70.39	$57.71	0.319	$18.39	0.187	$10.79	0.069	$3.97
13	-$12.93	$76.02	$63.09	0.290	$18.27	0.163	$10.25	0.055	$3.47
14	-$13.19	$82.10	$68.91	0.263	$18.15	0.141	$9.74	0.044	$3.03
15	-$13.45	$88.67	$75.22	0.239	$18.01	0.123	$9.24	0.035	$2.65
16	-$13.72	$95.76	$82.04	0.218	$17.85	0.107	$8.77	0.028	$2.31
17	-$14.00	$103.42	$89.43	0.198	$17.69	0.093	$8.31	0.023	$2.01
18	-$14.28	$111.70	$97.42	0.180	$17.52	0.081	$7.87	0.018	$1.75
19	-$14.56	$120.63	$106.07	0.164	$17.34	0.070	$7.45	0.014	$1.53
20	-$14.85	$130.28	$115.43	0.149	$17.16	0.061	$7.05	0.012	$1.33
		NPV			**$215.03**		**$87.80**		**-$24.87**

From the calculated NPV of different conditions, it is very clear that to mitigate revenue loss, pre-paid meter system will not be economically viable.

On the basis of Tables 5.4, 5.5 and 5.6 a summery table for discount rate of 15% is shown bellow in Table 5.7:

Table 5.7 NPV at different hours per day of 15% discount rate

Number of hours per day for misuse of gas	Discount rate	NPV
4 hrs at minimum opening with 8% increase of misuse	15%	-133.09
8 hrs at minimum opening with 8% increase of misuse	15%	- 45.67
2 hrs at minimum opening and 2 hrs at full opening with 8% increase of misuse	15%	+87.80

It is seen that if all burner are kept 2 hrs at minimum opening and 2 hrs at maximum opening per day for other than usual use then the project of meter system will be viable which is an absurd case. So pre-paid meter system will not be viable.

5.3 Public awareness Campaign

As it is seen that introducing an extensive Pre-Paid meter system to save comparatively insignificant amount of gas is not economically viable, a much better option is to do media campaign encouraging limited gas consumption. In this case large amount of gas would be saved. At the same time Government of Bangladesh will be benefited by promoting of LPG cylinders reducing dependency on pipe gas.

CHAPTER - 6

CONCLUSIONS AND RECOMMENDATIONS

6.1 Conclusions

Monthly gas consumption of a domestic customer derived from experimental data considering 8 hours per day use is 85.92 m3 which is very close to monthly tariff based gas consumption (87.146 m3) but according to gas distribution regulation 2004 and gas load calculation committee, monthly gas consumption of a domestic customer is 114.17 and 107.63 m3 respectively which is much more higher than real consumption. It is due to their design condition of higher pressure (0.28 psig) that is never available in domestic lines.

Assuming four hours of low flame burning in one burner for the entire TGTDCL customers as a wastage of gas, based on laboratory experiment the gas loss has been estimated to be 130.72 MMCM (4616.34 MMCFT) per year. The corresponding revenue loss for the wasted gas based on metered rate (Tk.5.16/m3) is Tk.674.63 million. In order to mitigate this revenue loss, it has been seen that pre-paid meter system is not economically viable due to high initial and operational cost.

So creating public awareness and introduction of gas cylinder system, the revenue loss can be mitigated to a large extent. At the same time loss or waste of gas will be significantly decreased.

6.2 Recommendations

In order to reduce revenue loss the following can be considered:

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

* Introduce auto ignition system burner or such a type burner which will start when burner will be loaded.

* Isolate different transmission and distribution systems to calculate appropriate system loss.
* Create public awareness.
* Introduction of gas cylinder system.

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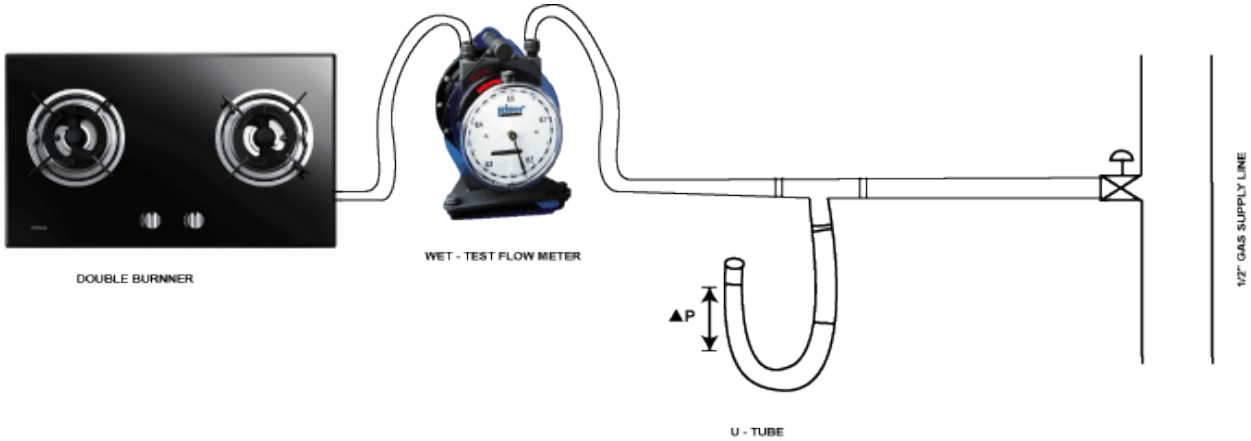
Appendix A- Titas Franchise Map

Figure – A1

Appendix B- Experimental Set up



EXPERIMENTAL SET - UP

Figure- B1

Appendix C- Results for gas flow and pressure variation

Table C1 Pressure variation with time for double burner

Time in hrs.	Differntial pressure in cm water height
6.3-8.3	6.8
8.3-10.3	7.2
10.3-12.3	6.6
12.3-14.3	7
14.3-16.3	7.2
16.3-18.3	7
18.3-20.3	7.2
20.3-22.3	6.6

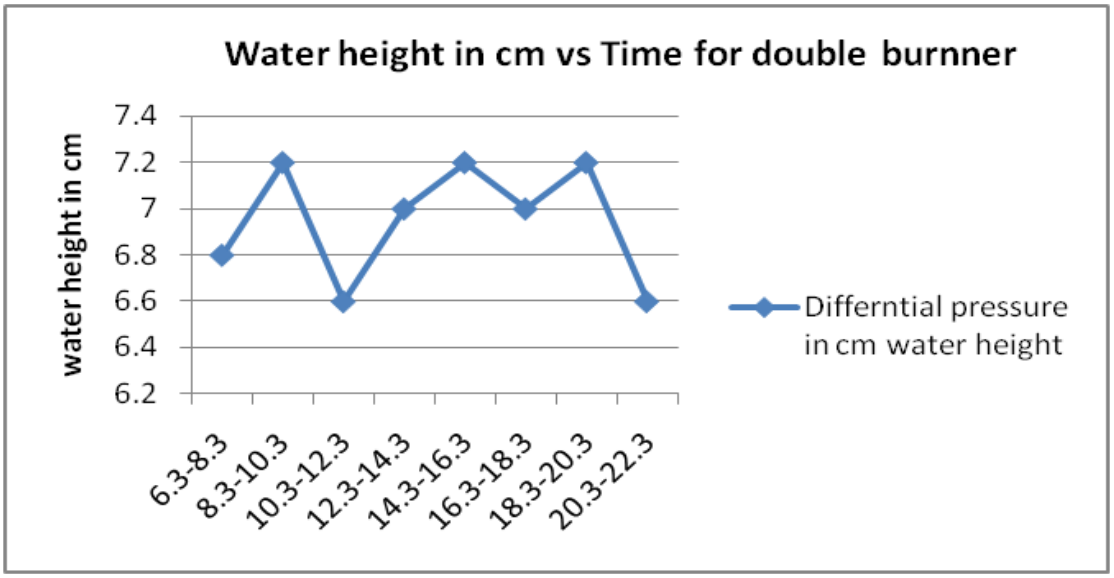


Figure C1 Pressure variation with time for double burner

Table C2- Flow rate variation with time for double burner

Time	Flow rate for double burnner
6.3-8.3	0.356
8.3-10.3	0.358
10.3-12.3	0.354
12.3-14.3	0.358
14.3-16.3	0.362
16.3-18.3	0.36
18.3-20.3	0.36
20.3-22.3	0.356

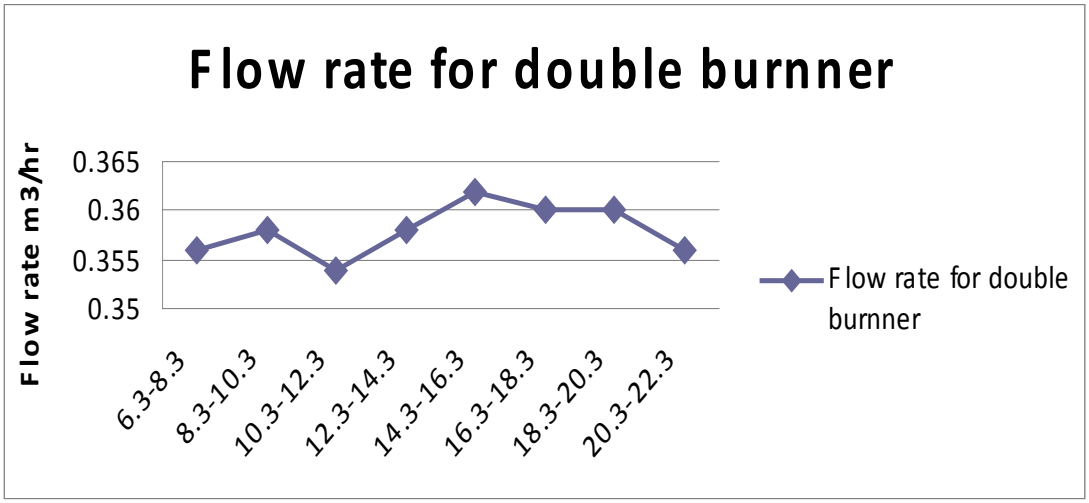


Figure C2- Flow rate variation with time for double burner

Table C3- Pressure variation with time for single burner

Time in hrs.	Differential pressure in cm water height
6.3-8.3	10
8.3-10.3	11.2
10.3-12.3	9.8
12.3-14.3	10
14.3-16.3	12
16.3-18.3	11.2
18.3-20.3	11
20.3-22.3	10

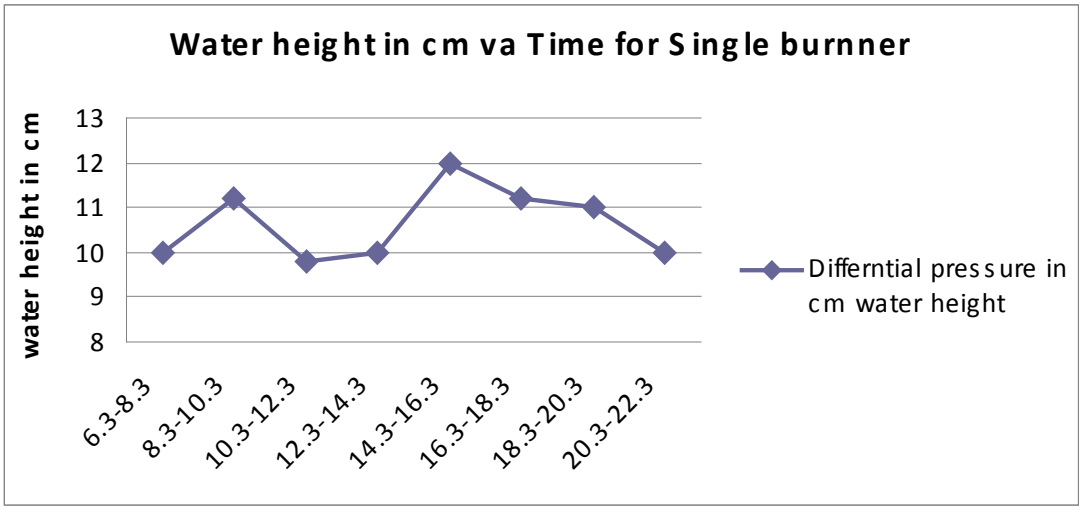


Figure C3- Pressure variation with time for single burner

Table C4- Flow rate variation with time for single burner

Time in hours	Flow rate for single burnner
6.3-8.3	0.21
8.3-10.3	0.22
10.3-12.3	0.2
12.3-14.3	0.21
14.3-16.3	0.224
16.3-18.3	0.22
18.3-20.3	0.22
20.3-22.3	0.2

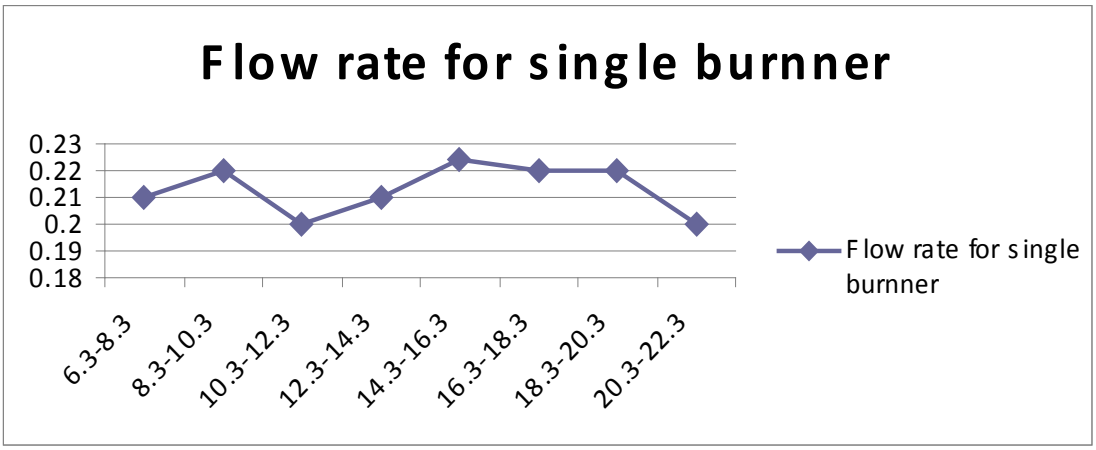


Figure C4- Flow rate variation with time for single burner

Table C5- Flame height vs differential pressure for double burner

Differential pressure in cm water height	Flame height for d. burnner in cm
7	9
6.5	6.6
4	6
3	5
2	1.5

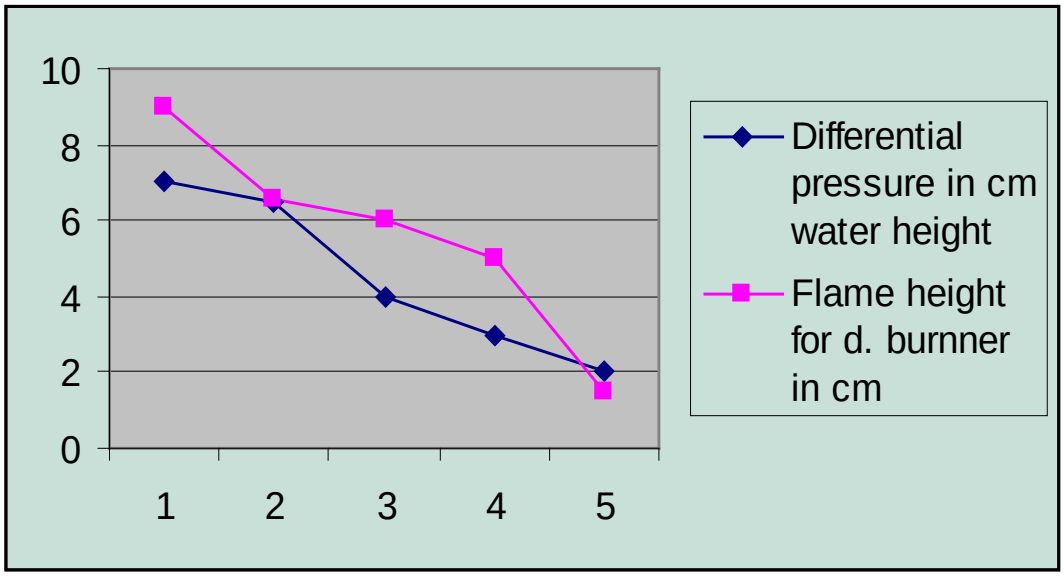


Figure C5- Flame height vs differential pressure for double burner

Table C6- Flame height vs differential pressure Single burner

Differential pressure in cm water height	Flame height for s. burnner in cm
11.2	13.5
10	11
9	9.6
7	6.8
6	6
4	5.5
2	3

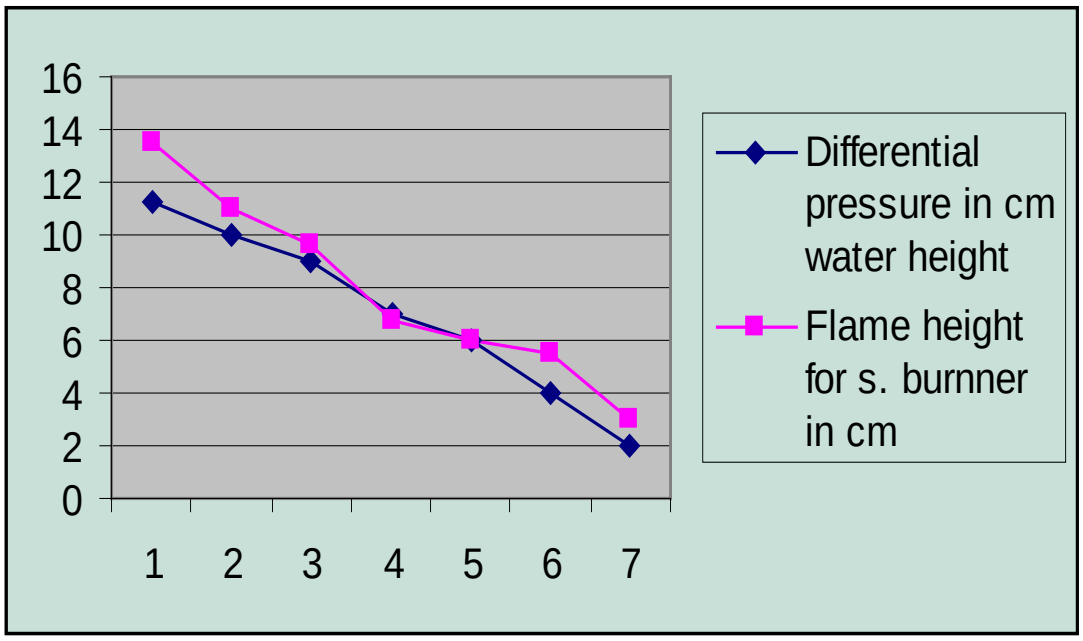


Figure C6- Flame height vs differential pressure for single burner