GAS PRE-PAID METERING AND ITS BENEFIT ANALYSIS IN TITAS GAS FRANCHISE AREA

by

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CANDIDATE'S DECLARATION

It is hereby declare 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 **"GAS PRE-PAID METERING AND ITS BENEFIT ANALYSIS IN TITAS GAS FRANCHISE AREA"** submitted by Md. Golam Sarwar, Roll Number--040213005(p), Session: April' 2002, has been accepted as satisfactory in partial fulfillment of the requirements for the degree of **Master of Petroleum Engineering** in April, 2007.

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TO MY LATE FATHER

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AAR	= Average Accounting Return
BCF	= Billion cubic feet
BASIC	= Bank of Small Industries & Cottage
BCR	= Benefit cost ratio.
BSCIC	= Bangladesh Small and Cottage Industries Corporation
CNG	= Compressed natural gas.
IICT	= Institute of Information and Communication Technology
IRR	= Internal rate of return.
JGTDCL	= Jalalabad gas transmission and distribution company limited.
MSCFH	= Thousand standard cubic feet per hour.
MMSCF	= Million standard cubic feet
MMCM	= Million cubic meter.
NPV	= Net present value.
PGCL	= Pashchimanchal gas company limited.
PBP	= Payback period.
PBB	= Present value benefits.
PI	= Profitability Index.
POS	= Point of Sales
PVC	=Present value cost.
RMS	= Regulating and metering system.
SGMS	= Selling Gas Management System
TGTDCL	= Titas gas transmission and distribution company limited.

SYMBOLS & TERMS

P_n	=	The value of P_0 at some future year, N.
P_0	=	The value of investment at year zero.
r	=	Interest rate.
n	=	The compounding period.
PN	=	Present value.
r	=	Discount rate.
R	=	The future value of R in year I.
I	=	Runs from year zero to year n.
bi	=	Benefits derived from the project in year i.
Ci	=	Cost(investment, operating and other associated expenses).
r_b	=	Higher discount rate.
r_a	=	Lower discount rate.
r*	=	IRR to be calculated.
NPVa	=	Net present value at lower discount rate.
NPV_b	=	Net present value at higher discount rat

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ABSTRACT

Titas Gas Transmission & Distribution Co. Ltd., a company of Petrobangla which is the largest distribution and marketing company of Bangladesh (72% market share) distributes and markets natural gas in Dhaka City and 21 regional offices outside Dhaka City. 7 (seven) Sales and Revenue zone offices exist in Dhaka City and there are 21 (twenty one) regional Sales offices outside Dhaka City, each having more or less 50,000 Domestic Gas Customers. Currently there are nearly 8,00,000 domestic consumers in the above areas of Dhaka City and the total number of domestic consumers in the Titas Franchise area is 10, 97,478 (up to December, 2006). These consumers are paying bills on monthly flat rate tariff under " Self Billing Process"

TGTDCL introduced some Pre-paid Gas meters in Banani area of Dhaka City as a pilot project. Under this project 1000 Pre-paid Gas meters have been procured, installed and commissioned in the customer premises. One of the objectives of this project work is to undertake financial analysis of using Pre-paid Gas meters. Financial parameters such as net present value (NPV), benefit cost ratio (BCR), internal rate of return (IRR), Pay back period and discounted pay back period and average accounting return (AAR) have been calculated on the basis of 20 year project life. The analysis is firstly done for 10,000 domestic customers. Then it is scaled up to all all the domestic customers in Titas Franchise area. The results of financial analysis infer financial feasibility of the project. Sensibility analysis is also made by varying the parameters such as Gas price, investment cost, gas consumptions through the proposed meters which are the guiding factors of financial indicators (NPV,IRR, BCR, Pay back period, discounted pay back period and AAR). Sensitivity is made considering the worst condition, the best condition and intermediate condition. Less variation in financial parameters for different conditions indicate that the project is less sensitive (less risky). The amount of waste gas for domestic consumers has also been calculated for not using the gas metering system. The amount of waste gas for all the domestic customers in Titas Franchise area are calculated as Tk. 30.73 crore annually.

CHAPTER – I: INTRODUCTION

Natural Gas is the most important natural resource of Bangladesh. It has extended its diversified uses in Power plants, Fertilizer factories as a feedstock, different Commercial, Industrial, Domestic and many other uses. The average daily production of gas fields in fiscal year 2005-2006 is 1500 MMSCF and yearly production is 540 BCF (Petrobangla 2005-2006). There are four separate distribution companies that are engaged in supplying Natural Gas to different types of customers in different regions. These companies are Titas Gas Transmission and Distribution Company Limited (TGTDCL), Bakhrabad Gas Systems Limited (BGSL), Jalalabad Gas Transmission and Distribution Company Limited (JGTDCL) and Pashchimanchal Gas Company Limited (PGCL). They construct and handle distribution lines and conduct marketing activities. Table- 1.1 shows salient features of these distribution companies.

Table- 1.1: Natural Gas Distribution companies in Bangladesh

Name of the company	Year of establishment	Controlling areas	Total pipe length in the network (up to 2004) km	Total no of customers (Up to Dec. 2006)	Annual Gas sales (2004) bcf
TGTDCL	1964	Dhaka Division including Brahmanbaria	8,476	11,81,218	275.8
BGSL	1980	Chittagonj Division excluding Brahmanbaria	5,115	3,69,139	86
JGTDSL	1986	Greater Sylhet District	2295	1,00,878	21.3
PGCL	1999	Northwest region.	219	24,416	17.53

(Source: Annual report, 2004-2005& monthly report, January 2007 of Petrobangla)

Titas Gas T & D Co. Ltd (TGTDCL) is the oldest and largest gas marketing company supplying 72% of the total gas consumed in the country. TGTDCL has a franchise area extending over the area east of the Jamuna- Padma river system, excluding the Sylhet and Chittagong divisions, but including Brahmanbaria. TGTDCL is incorporated on 20th November1968. The company is working under the supervision of the corporate body named Petrobangla and the Administrative Ministry- Ministry of Power, Energy & Mineral Resources. Sources of gas supply of TGTDCL are Titas, Habiganj, Rashidpur, Bianibazar, Kailashtila, Jalalabad & Narshingdi Gas fields. By the end of June 2006, the company had under its operation a network of 9,816.29 km pipeline, which included about 735 km transmission. 383 km distribution and rest feeder mains and service lines. By the end of June 2006, the company had a customer base of 11,10,175.Among the bulk customers of TGTDCL, there are 24 power (including private) and 4 fertilizer plants. During the 2005-2006 financial year, TGTDCL sold 358.957 bcf gas to its customers, of which power and fertilizer plants consumed 157.32 bcf and 48.705 bcf respectively. The large domestic customer base of TGTDCL accounted for about 38.162 bcf gas. TGTDCL is laying new pipe lines every year to meet the increasing demand for gas. The company has been making remarkable contribution towards the economic progress of the country. During the 2005-2006, TGTDCL earned sales revenue of Tk.3408 crore and a net profit of Tk.206.40 crore, which is 38.04% higher than the previous year. The company provided 68,443 new connections, which is 9.79% higher than the previous year. The system loss during the period was 6.47%, which was 0.59% less than the previous year indicating a saving of Tk.17.0 crore. TGTDCL has produced e-governance system for providing improved and transparent services to industrial customers, enabling the prospective customers to know the latest position of their applications on website.

The discovery of large reserve of natural gas has stimulated demand for this clean, cost-effective energy source, resulting in rising investment and rapid expansion of transmission and distribution networks. Gas metering quality has become a critical issue for transportation and distribution companies over the last decade. The main reasons for this issue are higher energy costs, the adaptation of the industry to deregulated markets throughout the world, the need for fair dealing between buyer and seller and the increasing involvement of official measuring authorities. As it plays a direct role in determining the revenues of gas companies, metering is a vital function requiring optimal accuracy and dependability.

1.1 Present scenario of gas metering system in Bangladesh.

In Bangladesh, four marketing companies are selling natural gas to the customers of different nature such as- Power, fertilizer, tea garden, seasonal (for example-brick field), CNG, industry, commercial and domestic. Except domestic, for all other customers, meters are used for fiscal measurement of natural gas. Post-paid analogue meters are used for measuring the quantity of gas supplied. The related customer is billed multiplying the gas quantity at standard condition with the gas tariff applicable for that particular customer. TGTDCL supply gas to all types of customers mentioned above except tea garden. All types of customers except domestic are billed knowing the gas quantities from meters. To very few extents, such as flats, meters have been installed in case of domestic customers.

Though the quantity of gas used by a single domestic customer using a double burner is low (tested load of 21cft/hr as estimated by the load survey committee of TGTDCL), due to the large number (10,97,478 up to June, 2006 in Titas franchise area) of domestic customers , the total amount of gas consumed by these customers is high comprising 11% of the total amount of gas consumed. Day by day the number of domestic customers is increasing at a faster rate. The main problems of un-metered domestic customers are wastage of gas and collection of dues. If gas can be sold in credit through a reliable system, the wastage of gas can be reduced and there will be no dues to the customers.

With a view to the above matter, Titas Gas T&D Co. Ltd has taken a pilot project at Banani area in Dhaka city. Under this project, it has installed 1000 meters in 1000 kitchens at this residential area. The features of the pilot are described below.

Timeline : July,2005 to September,05

Number of Units : 1000

Location : Banani, Dhaka.

Financier : TGTDCL

Supplier : Hangzhou Beta-Aziz & Co JV.

Meter Specifications:

Type: Diaphram meter

Model: G-1.6 A

Qmax= 2.5m3/ hr

Qmin= 16 dm3/ hr

Pmax= 100Kpa

It is necessary to focus on various merits and difficulties, customer's satisfaction, dissatisfaction, change in revenue etc experienced in the project. Moreover, it is necessary to conduct financial analysis.

1.2 Objectives of the project

(i)To study the justification of pre-paid gas metering system.

(ii) To estimate the amount of wasted gas (if any) by domestic customers.

(iii) The viability of pre-paid gas metering system for domestic customers.

1.3 Methodology

I) Detail study of the pre-paid gas metering pilot project
- Manner of implementation, related literature.
- Costs involved and revenues earned
- Customer feed back
- Estimation of wasted gas by flat-rate customers.

II) Financial analysis.

CHAPTER-2: BRIEF OVERVIEW OF GAS MARKETING

Natural gas has diversified use. At one extreme, it is used in a large quantity for a power plant, whereas a single domestic customer at other extreme uses it in a very small quantity.

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 purchase, revenue and other statistics.

2.1 Classification of gas users

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 customer
3) Industrial customer
4) Seasonal customer
5) Tea-state customer
6) CNG

B) Bulk customer

7) Power producing
8) Fertilizer producing customer
9) Captive power producing customer.

Definition and characteristics of various types of customers are as follows:

1. Domestic customer

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

(i) Domestic metered

(ii) Domestic un-metered.

Domestic metered customers: In Titas Gas franchise area, most of the domestic customers are un-metered. Very few domestic customers are metered. In many flats, meters have been installed through which gas is delivered and billed on the basis of consumptions through the meters.

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.

2. Commercial Customer

This type of customers includes the following.

1. Hotels and Residential Hotels
2. Shops. Factories which are producing sweetmeat
3. Restaurants/Chinese Restaurants, Canteens and Tea-stalls
4. Chira , Mori producing factory
5. Private clinics,Laboratories,Hospitals
6. Community Centers
7. Snacks, Kababghors
8. Bakeries. Confectioneries, Chocolates. Chanachure, Shemaie, Biscuit producing factories (Hand operated)
9. Shop/Pottery/Ceramic/Paint/Medicine producing factories (Hand operated)
10. Distilled water/Dieing and Printing/Laundry/Tannery/Shari producing factory (Hand operated)
11. Ice/Ice cream producing factory (without machine).

3. Industrial Customer

1. Small and Cottage industries situated in Bangladesh Small and Cottage Industries Corporation (BSCIC) industrial estate.
2. Machine operated factory installed personally or with the help of various money-lending organizations like Shilpa Poridaptar, Bank of Small Industries & Cottage (BASIC) etc.

3. Large scale industry/factory/organization and hotel, which are using boiler, generator etc
4. Factories, which are producing brick, tiles, ceramic, refractory, centenary and electrical, and others goods by machine.
5. Machine operated ice/ice-cream producing factories.

4. Seasonal Customer

1. Seasonal manual brick producing factories.
2. Seasonal tobacco leaf drying factory.
3. Seasonal sugar cane and fruit processing industries.

5. Tea-State Customer: Tea-state customers are those who use gas for tealeaf drying processing and related works (except generator for power generation).

6. CNG (Compressed Natural Gas)

CNG customers are those which compress natural gas to higher pressure(from 50 psig to 3000psig)

7. Power Producing Customer: Power station owned by Bangladesh Power Development Board, in large scales any other Government and non-Government Electricity Generating Plants using Natural Gas. Power producing customers are Govt., Independent Power Producer (IPP), Small Independent Power Producer (SIPP) and Captive Independent Power Producer (CIPP).

8. Fertilizer Producing Customer: Government and non-Government Fertilizer producing factories that are using Natural Gas as feedstock.

9. Captive Power Customer:
Customers who are producing power for their own use with gas Generator using Natural Gas as fuel.

Tariff rates for different Customer bases with different are shown in the table-2.1.

Table-2.1: Different Customer Bases

Types of customer			Tariff rate (Tk/ m3)
A. Non Bulk Customer	1. Domestic	a. Domestic metered	4.59
		b. Domestic un-metered (flat rate)	Double Burner: Tk 400/month Single Burner: Tk 350/month
	2. Commercial		8.23
	3. Industrial		5.23
	4. Seasonal		5.23
	5. Tea-state		5.23
	6. CNG		2.47
B. Bulk customer	7 Power producing customer	Govt.	2.61
		IPP	4.41
		CIPP	3.73
		SIPP	3.73
	8. Fertilizer producing		2.24
	9. Captive power producing		3.73

(Source: Bangladesh Gazette- order published on January, 11, 2005)

2.2 Natural Gas Customer Base

Four marketing companies that are supplying natural gas to different customers in different regions of Bangladesh are TGTDCL, BGSL, JGTDCL, and PGCL. TGTDCL is the largest gas marketing company in Bangladesh. The second largest gas marketing company in Bangladesh is BGSL. JGTDCL and PGCL are third and fourth respectively. These companies supply gas to their respective franchise areas. Different types of customers handled by four marketing companies (up to December, 2006) are shown in the table-2.2

Table- 2.2: Gas customer status of four marketing companies
(Up to December 2006)

Category of Customers	Titas Gas area	Bakhrabad area	Jalalabad area	West gas area	Total
Power (including IPP, CIPP, SIPP)	24	5	3	3	35
Fertilizer	4	3	1	-	8
Captive power	453	102	28	6	589
Industry	3,735	957	42	42	4,776
Commercial	8,947	3,851	876	159	13,833
Tea garden	-	1	89	-	90
Brick field	12	-	-	-	12
CNG	99	26	5	5	135
Domestic	11,81,218	3,69,139	1,00,878	24,416	16,75,651
Total	11,94,492	3,74,084	1,01,922	24,631	16,95,129

(Source: Petrobangla, 2007)

The numbers of customers handled by TGTDCL in different category are shown in the Table-2.3

Table-2.3: Gas Customer Status of TGTDCL

Category of customers	Total No of customers as on 31Dec. 2006
Power	10
IPP, SIPP	06
CIPP	08
Fertilizer	04
Industrial	3,735
CNG	99
Commercial	8,947
Seasonal	12
Domestic	11,81,218
Captive	453
Total	11,94,492

(Source: Monthly report, January 2007 of TGTDCL)

Table 2.3 shows that TGTDCL handles a large number of domestic customer base of 11,81,218(up to Dec, 2006). TGTDCL supplies gas to 4 Govt and 14 non-govt power plants which supply electricity to national grid. In TGTDCL franchise area, gas is supplied to 4 fertilizer factories. The number of captive power customers (those which produce electricity for their own use), which receive gas from Titas Gas, is 453. There are 3,735 industrial, 8,947 commercial and 99 CNG customers in Titas Gas franchise area.

2.3 Gas sales and purchase by Titas Gas

Gas sales are increasing every year. The actual figures of gas sales and gas purchase for the financial year 2005-2006 were 10164.52MMCM & 10875.80 MMCM respectively. Gas sales in different category are shown in the table-2.4

Table-2.4: Gas sales and purchase by TGTDCL (2005-2006)

Category of customers	Actual sales (MMCM)	Actual purchase (MMCM)
Power	4,754.70	5,090.39
Fertilizer	1,379.19	1,475.61
Industrial	1,509.67	1614.25
CNG	154.50	165.05
Commercial	93.96	100.51
Seasonal	-	-
Domestic	1,122.07	1,155.72
Captive	1,150.43	1,229.92
Total	10,164.52	10,875.80

(Source: Annual report 2005-2006 of TGTDCL)

It is mentionable that the growth rate of gas sales was 11.47% with respect to previous FY 2004-2005.

The gas sales in different category are also shown in the following figure-2.1

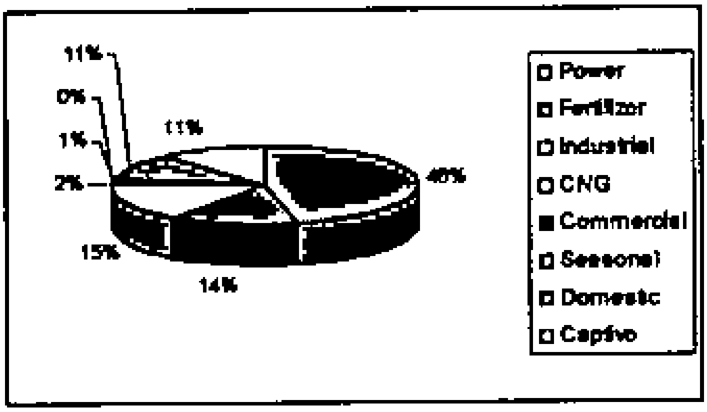


Figure -2.1: Category wise gas consumption (2005-2006)

Except in fertilizer sector, gas sales of TGTDCL increased during the FY 2005-2006 in comparison with FY 2004 -2005.The comparison of gas sales in these two financial years is shown in the figure -2.2.

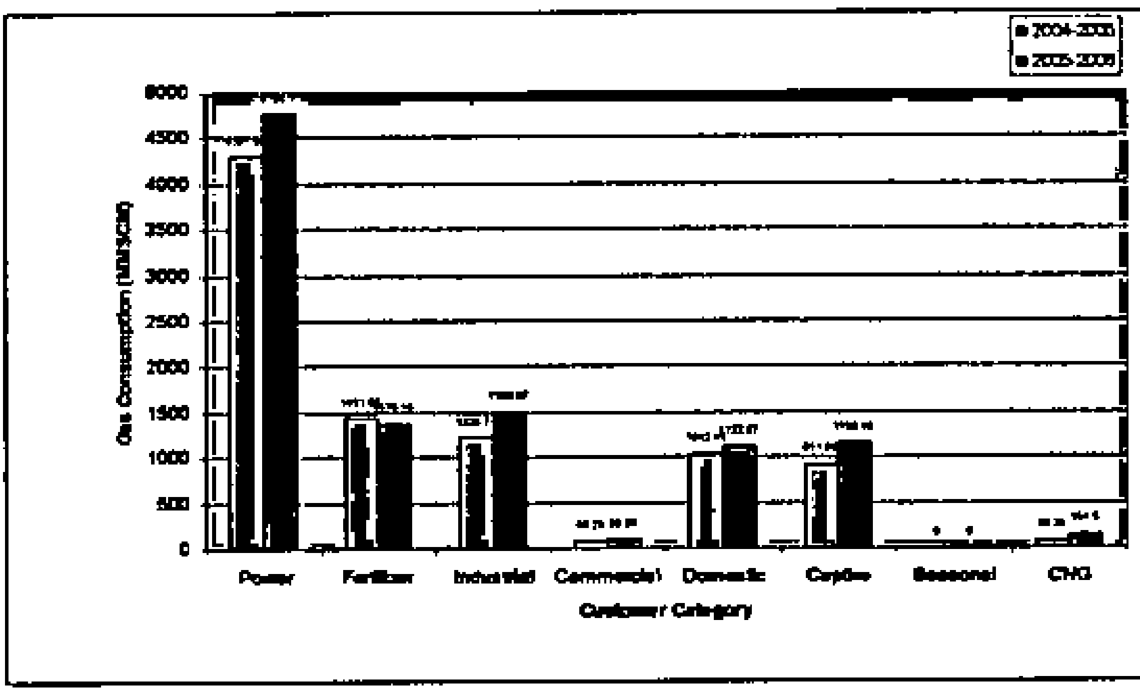


Figure 2.2: Customer category wise gas consumption (2004-2005& 2005-2006)

Market Share of Gas Marketing Companies

Relative market shares of four companies on the basis of gas sales (MMCM) for the FY 2005-2006 are shown in the figure -2.3

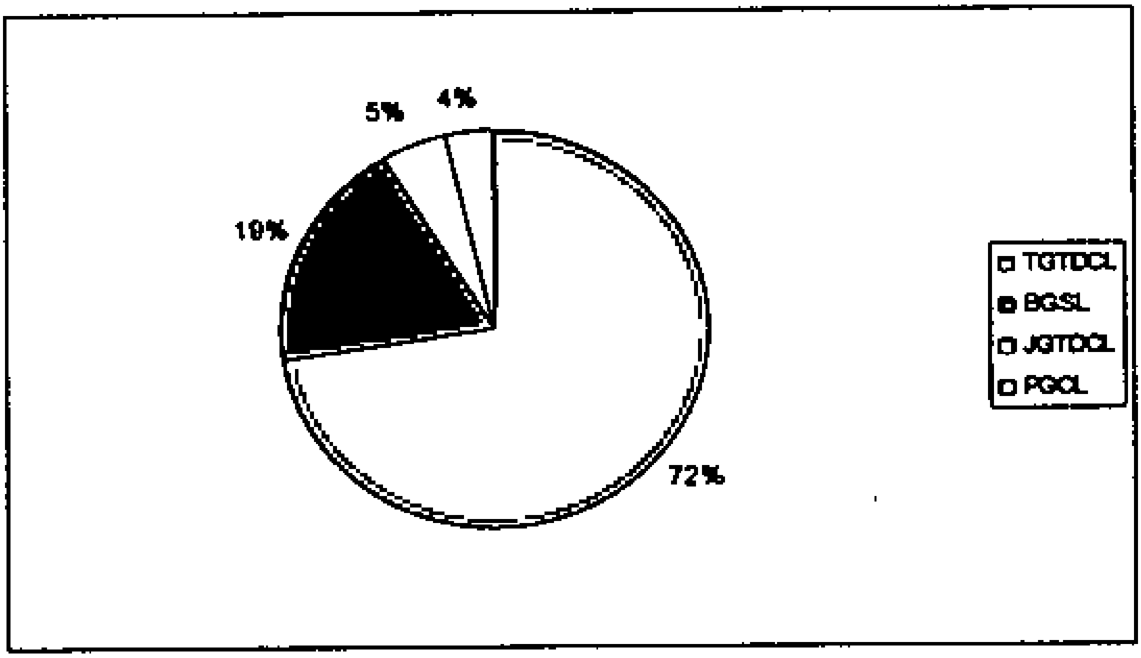


Figure -2.3: Gas sales of four marketing companies for the FY 2005-2006

2.4 Statistics of Arrear Revenue in Titas Gas franchise areas

In spite of the increased effort of the company to collect arrear gas bills during the year, due to unsatisfactory realization of arrears from the disconnected, litigant and Govt/semi-Govt customers arrear revenue stood at 1328.78 crore which is equivalent to 4.42 months' gas bill. Arrear gas bills are shown in the table-2.5

Table-2.5: Statistics of Arrear /Dues (2005-2006)

Category of customers	Arrear (Crore Taka)
PDB	298.21
Private power	127.56
Fertilizer	83.14
Industrial	503.64
CNG	9.26
Commercial	38.10
Seasonal	4.72
Domestic	342.51
Captive	154.34
Total	1,561.48
Bad debt	232.70
Net arrear	1,328.78

Source: Annual report 2005-2006 of TGTDCL

CHAPTER -3: OVERVIEW OF GAS METERING PRACTICE IN TITAS GAS T& D CO. LTD.

When metering is used for billing purposes, the essential value sought is the energy consumed. To obtain this value, the volume at reference conditions must be known. This information is then processed manually using the average volumetric calorific value to obtain the corresponding energy.

A metering chain includes one or more primary sensor corresponding to auxiliary functions of processing and correction. History and experience have confirmed the superiority of direct volume measuring systems (meters). These meters measure the volume of a given gas, which is then computed and shown on an index (Totaliser) (www.actaris.com). In this chapter, classification of gas meters, their working principle, advantages and disadvantages and selecting criteria will be discussed.

3.1 Classification of Gas Meters

Based on wide use, two broad classes of meters are used to measure gas volumes produced, transported, bought and sold: 1) positive displacement 2) inferential. Positive displacement meters include the diaphragm and rotary. Inferential meters include the orifice and turbine. Other meters such as the mass flow, quanto, ultrasonic meters are not widely used.

3.2 Brief description of different meters

3.2.1 Positive Displacement Meters

Positive displacement meters measure the gas quantity passing through them by alternately filling and emptying one or more chambers in sequence. Each chamber's volume is known and the operating cycles are counted to get the gas volume passed. This class of meter measures total flowing volumes by repeatedly filling and discharging fixed volumes. Many different designs are available; however they are divided into three broad classes. In the first class is the meter in which one wall is of a flexible material that moves to displace the volume with no leakage into another chamber. An example of this type is the diaphragm meter. In the second class are meters in which a mechanical seal is used between movable and stationary walls. The rotary meter is an example of this class. The third class employs a capillary element, an example being the capillary seal meter used for liquid measurement.

a) Diaphragm Displacement Meters

The most common example of this meter is the domestic gas mater. These meters are produced with a G – rating range from G – 1.6 to G – 10 with operating pressure 0.4 bar and this is the most widely used positive displacement meter for gas applications. The operation of this meter is simple and proven, having been in service for over 100 years. In this type of meter there are two chambers alternately fill and empty, with slide valves at the top of the meters controlling the flow to the chambers. The gas volume is obtained through a mechanical linkage mechanism, which connects the diaphragm motion to the mechanical readout system, where the number of displacements is counted. Mechanical reliability is very high. In TGTDCL system this type of meter is being over 30 years. Due to their production in large quantities, they are inexpensive to purchase. The positive displacement meter can also be used for commercial and small industrial applications; however they are used for low to medium flow rates and are limited to low pressure. The diaphragm meter is shown in Figure-3.1

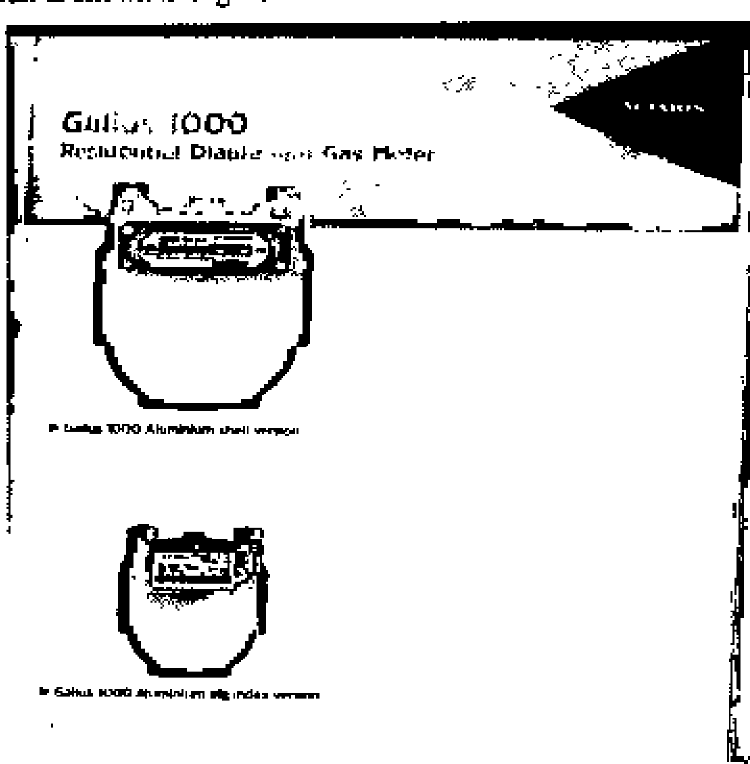


Figure-3.1: Positive Displacement Diaphragm Meter

(Source: Gas book of actaris / www.actaris. Com)

Advantages of positive displacement meters are as follows:

1) Cheap

2) Well tried and proven

3) High reliability

4) Very good range ability

Disadvantages of positive displacement meters are as follows:

1) Malfunction will stop flow

2) Low-pressure operation

3) Bulky for large volume flows

4) Pulsations introduced into the flow

5) Very easy for gas pilferage by making a leak or hole into the diaphragm.

Different Residential Meters:

Different types of diaphragm meters are used to measure volume of natural gas for domestic customers. Some of these are described below.

1) Gallus 1000 Residential Diaphragm Gas Meters:

Basic Features.

Compact size

0.7 dm^3 cyclic volume

G 1.6

Design:

Aesthetic and robust design

Long-term accuracy and safety

Ready for remote reading and data management

Gallus 1000 is a very compact residential gas meter designed to measure accurately volumes of natural gas, LPG and all non-corrosive gases.

During the preliminary test controls on the test benches, the meters are tested at Q_{min}, $.2Q_{max}$, and Q_{max}.

Operating Principle:

Gallus 1000 is a positive displacement diaphragm meter with a built-in twin-chamber measuring unit Each chamber is equipped with a flexible, gas tight diaphragm, which is displaced by the differential between inlet and outlet pressure. The gas enters one side of the diaphragm pan while on the other side it comes out through a separate port on the valve. When one side is full, the rotating mono- valve moves on to the next position, allowing gas to fill the empty side.

A transmission gear and a mechanical staffing box transfer the reciprocating motion to the mechanical retrofit table index

The measuring unit is housed in a gas- tight, aluminium casing.

Technical Characteristics:

Technical Characteristics are shown in the table-3.1

Table-3.1: Technical Characteristics of gallus 1000 Diaphragm meter

Gas Type	NG / LPG / All non corrosive gases
Cyclic Volume	.7 d m^3
Operating temperature	- 20^0c to + 50^0c
Storage temperature	- 40^0c to + 60^0c
Maximum operating pressure	1.5 bar
Metering range	Q_{min} = 0 016m^3/ hr Q_{max}= 3 m^3/ hr
Pulse generator	Standard 0.01 m^3/ pulse, Optional 0.1 m^3/ pulse or 1 m^3/ pulse
Pulse transmitter	Retrofittable LF-system, 12 vdc max- 10mA max standard 0.01 m^3/ pulse, 0.1 m^3/ pulse or 1 m^3/ pulse upon request.
Casing material	aluminium with aluminium or steel shells

(Source: Gas book of actaris / www.actaris. Com)

2) Gallus 2000 Residential Diaphragm Gas Meters:

<u>Basic Features:</u>

Compact size

1.2 dm^3 cyclic volume

Range G 1.6, G2.5, G4

<u>Design:</u>

Long-term accuracy and safety

Ready for remote reading and data management

Gallus 2000 is a very compact residential gas meter designed to measure accurately volumes of natural gas, LPG and all non-corrosive gases.

During the preliminary test controls on the sonic nozzle test benches, the meters are tested at Q_{min}, $.2Q_{max}$ and Q_{max}

Gallus 2000 residential gas meter is shown in figure 3.2

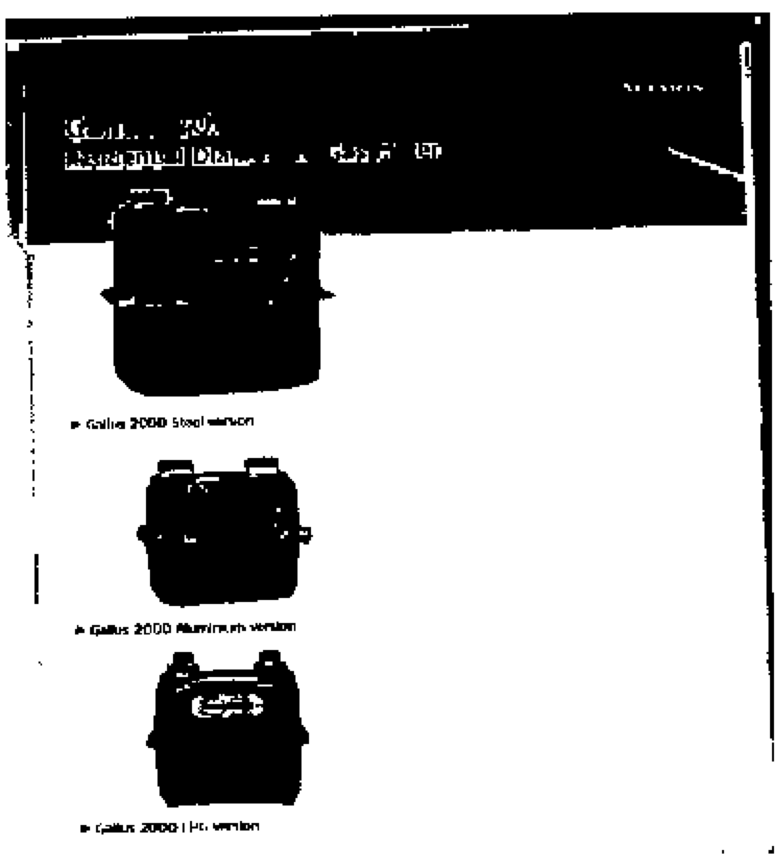


Figure 3.2: Gallous 2000 residential gas meter
(Source: Gas book of actaris / <u>www.actaris</u>. Com)

Technical Characteristics:

Technical Characteristics are shown in the table-3.2

Table-3.2: Technical Characteristics of gallus 2000 Diaphragm meter

Gas Type	NG / LPG / All non corrosive gases
Cyclic Volume	1 2 dm^3
Operating temperature	- 20^0c to + 50^0c
Storage temperature	- 40^0c to + 60^0c
Maximum operating pressure	.5 bar for steel version 1.5 bar for Aluminium version
Metering range	G 1.6 : Q_{min} = 0.016m^3/ hr Q_{max}= 3 m^3/ hr G 2.5 : Q_{min} = 0.025m^3/ hr Q_{max}= 4 m^3/ hr G 4 : Q_{min} = 0.04m^3/ hr Q_{max}= 6 m^3/ hr
Pulse generator	Standard 0.01 m^3/ pulse, Optional 0.1 m^3/ pulse
Pulse transmitter	Retrofittable LF-system, 12 vdc max-10mA max standard 0.01 m^3/ pulse

(Source: Gas book of actaris / www.actaris. Com)

RF1 G6 - Residential Diaphragm Gas Meters:

Basic Features:

Compact size

2 dm^3 cyclic volume

Range G 1.6, G2.5, G4, G6

Design:

Long-term accuracy and safety

Ready for remote reading and data management

Robust construction

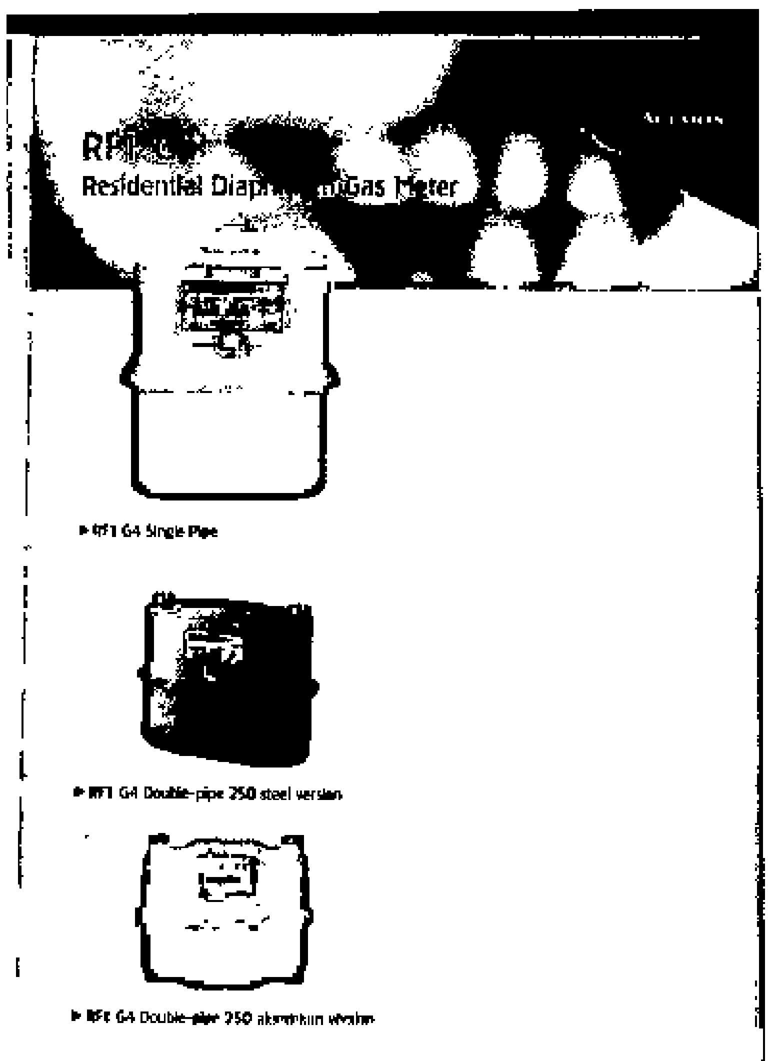
Environment friendly

RF1G6 is a very compact residential gas meter designed to measure accurately volumes of natural gas, LPG and all non-corrosive gases.

During the preliminary test controls on the sonic nozzle test benches, the meters are tested at Q_{min} , .$2Q_{max}$, and Q_{max} .

RF1G6 residential gas meter is shown in figure 3.3

Figure 3.3: RF1G6 residential gas meter



(Source: Gas book of actaris / www.actaris. Com)

Technical Characteristics

Technical Characteristics are shown in the table-3.3

Table-3.3: Technical Characteristics of RF1 G4 Diaphragm meter

Gas Type	NG / LPG / All non corrosive gases
Cyclic Volume	2 dm^3
Operating temperature	- 10^0c to + 50^0c (option -20^0c to + 50^0c)
Storage temperature	- 40^0c to + 70^0c
Maximum operating pressure	.5 bar for steel version 1.5 bar for Aluminium version
Metering range	G 1.6 . Q_{min} = 0.016m^3/ hr Q_{max}= 2.5m^3/ hr G 2.5 : Q_{min} = 0.025m^3/ hr Q_{max}= 4 m^3/ hr G 4 : Q_{min} = 0.04m^3/ hr Q_{max}= 6 m^3/ hr G 6 Q_{min} = 0 06m^3/ hr Q_{max}= 10 m^3/ hr
Pulse generator	Standard 0.1 m^3/ pulse, Optional 0.01 m^3/ pulse
Pulse transmitter	Retrofittable LF-system, 12 vdc max- 10mA max standard 0.1 m^3/ pulse

(Source: Gas book of actaris / www.actaris. Com)

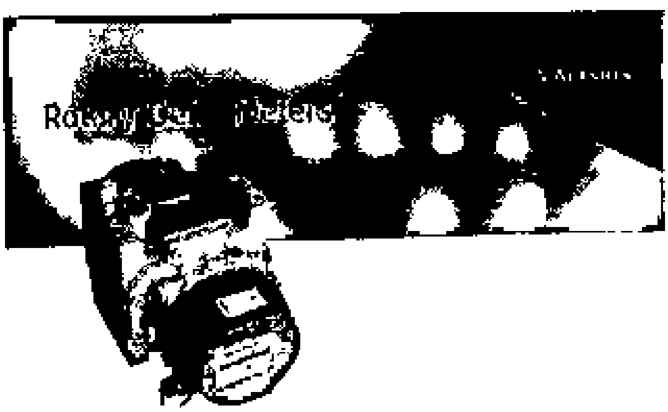
b) Rotary Meter:

The rotary meter contains two counter-rotating impellers, which trap a known gas volume on each rotation. Like the diaphragm meter, the passed gas volume is shown in a counter which totals the cycles operated. The rotary meter's capacity rating is much greater than the diaphragm's. Rotary meters can be used in high-pressure applications with up to an ANSI 600 rating available. The volume of gas is directly related to the number of revolutions of one of the impeller shafts. Good range ability can be obtained for the rotary meter. These meters are compact and reliable, however since the operation depends on maintaining proper clearance between the impellers and the case, they can be susceptible to stress and if a malfunction occurs, then the gas flow could be stopped. The rotary meter is limited at high pressure. Therefore, this meter although an excellent performance is not regarded as appropriate for large capacity, high pressure metering of Natural Gas.

Accuracy is within 1% for loads from 5 to 100% (20:1) of the meter capacity; below 5%, accuracy drops sharply.

A rotary meter is shown in figure-3.4

Figure-3.4: Rotary meter



(Source. Gas book of actaris / www.actaris. Com)

Advantages of Rotary Meters:

Good range ability

Compact design

Good accuracy

Insensitive to upstream flow conditions.

3.2.2) Inferential Meters

Orifice and turbine meters operate on the inferential measurement principle. Here the flow rate is found by inferring from other measured variables.

i) Orifice Meters:

Orifice Metering is the most common form of gas metering used throughout the world for the accounting of large volumes of natural gas. It is also used for the measurement of liquids.

Based on the differential pressure method, the rate of flow is computed on the basis of long established physical principles. The common equation used for determining the total flow volume being based on the current American Gas Association (AGA) or International Standard Organization (ISO) Standard.

The orifice plate meter is classified as a differential pressure (dp) meter. There are a number of types of flow meters, with different shapes and sizes, which fit into this category of inferring flow rate from the pressure drop across a restriction. An Orifice plate flow meter system consists of three discrete components - the meter tube, the orifice assembly, and the differential pressure gauge. The meter tube and orifice assembly are considered to be the primary element and the differential pressure gauge, pressure and temperature gauge or recorder are being referred to as secondary element.

Meter Tube:

The meter tube is an important component and it contributes greatly to the overall accuracy of the primary element. There is a downstream section and an upstream section.

The tube must be specially selected for dimensional accuracy and for concentricity.

To determine the length of the meter tubes, four aspects must be considered:

-Maximum beta ratio, β which is numerically orifice diameter divided by pipe diameter.

-Position of the pressure tapping

-Use of straightening vanes

-Upstream fittings.

It can be seen that the installation of straightening vanes considerably reduces the length of straight pipe required upstream of the orifice plate. The function of the vanes is to eliminate the effect of swirl and crosscurrent caused by pipefitting and valves preceding the meter tube.

Orifice Assembly:

There are two main types of orifice assembly: Double chamber and single chamber. Both types of assembly can be supplied with flanges each side, or with a flange on the downstream end and a weld preparation on the upstream inlet side.

Single Chamber:

Single chamber orifice assemblies, sometimes referred to, as dead line types, require the flow to be stopped and the pipeline depressurized before the orifice plate can be removed.

Double Chamber:

Double or dual chamber orifice assembly allows the removal of the orifice plate without the necessity to stop the flow or depressurize the pipeline. These assemblies save the need for costly bypass piping and valves, and enable one person to remove and replace an orifice plate in a relatively short time.

Orifice Plate:

The orifice plate, possibly the most important component of the primary element is also the least expensive. Case must be taken in the designing, machining, handling, storing and installing the orifice plate.

Usually the orifice plate is manufactured from the stainless steel plate. Case is taken during machining to prevent the formation of stresses, which could cause bowing. The plates are finished after machining, and inspected to confirm that the square edge on the bore remains sharp and burr free. Orifice plate sealing units are molded in a variety of synthetic rubber materials.

The orifice plate meter is classified as a differential pressure (dp) meter. There are a number of types of flow meters, with different shapes and sizes, which fit into this category of inferring flow rate from the pressure drop across a restriction. An orifice plate flow meter system consists of two basic elements, namely the primary flow element, which is the orifice plate, and secondary elements which include the differential pressure transmitter, or differential pressure indicating device such as a manometer, and the associated pipe work and valves. The orifice plate meter relies on the principle: when a fluid is flowing a closed medium (a pipe) and encounters a restriction, a pressure drop is developed. This pressure drop is related to the flow rate of the fluid. By measuring the differential pressure across the orifice plate (upstream and downstream of the plate) and the condition at which the orifice is being used, then this pressure differential can be translated into a volume flow rate according to a formula. If malfunctions occur, the flow of gas will not be stopped. Orifice meters are not limited by high pressure or high flow. So they can, therefore, be considered for high flow, high pressure gas metering. Naturally the correct selection of orifice plate type is important.

The range ability of a single orifice meter is about 3:1. By adding further orifice meter runs in parallel, this range ability increases by the square. That is, a dual run meter station would have a theoretical range ability of approximately 9:1. Range ability is the term used with meters to express the flow range over which a meter operates whilst continuing to meet a given accuracy tolerance. The range ability can also be expressed as 'turndown', which is a ratio of the maximum flow divided by the minimum flow, again over a given accuracy tolerance.

While there is much progress in flow metering, the orifice plate meter is still in wide use owing to its robustness and simplicity. This is particularly the case in North America. There is no doubt that a contributing factor to the continued popularity of the orifice plate is the 'comfort factor' it gives, that is it is a tried, proven and reasonably diverse flow meter.

Although the orifice plate does not normally require calibration, the differential pressure transmitter does require regular verification if the best standards of accuracy are to be maintained.

The orifice plate has been used for flow measurement applications for about 100 years; therefore, considerable data has been collected on its performance and applications. A number of variants have been developed where the profile of the plate and the location of the differential taps can be significantly different. The orifice plate meter is designed for unidirectional flow. Should reverse flow occur, or the plate installed in reverse, a substantial flow error in the order of 20% may be observed.

Important features of the plate are the requirements for, a sharp square upstream edge, that the plate itself having sufficient thickness to withstand the expected flow characteristics (withstand buckling), and have a beveled downstream edge for applications where a thin plate can be used, the downstream bevel requirement may not be possible. There are generally three types of pressure taps used, being corner, flange and pipe.

In an orifice meter the measured variables are the differential pressure across an orifice plate, flowing gas temperature and static pressure. These variables are recorded on a circular chart, then integrated to find flow rate. Orifice meters must be designed, fabricated and installed according to AGA Report # 3 (ANSI/API 2530). When designing an orifice meter run, differential pressure should range between 10" and 90" of water column for a 100" chart and 20" and 180" of water column for a 200" chart. This avoids large measurement errors at low differential pressures and overhanging the chart.

Although AGA Report # 3 does not specify upper or lower differential pressure limits, industry standard is 10" to 200" of water column. If the differential pressure falls below 10" of water column, it does not stabilize and measurement errors result.

Tolerable Pressure Drop: Pressure downstream of an orifice plate recovers 50% of the pressure drops across the plate within 4.5 pipe diameters downstream of the plate.

Modern orifice meter installations calculate flow using flow computers rather than charts. Orifice meters can be installed with multiple differential pressure transducers (stacked) for greatly improved range ability. If a differential pressure transducer is not in a temperature-controlled environment, a temperature compensated differential pressure transducer is used.

Errors for orifice measurement devices are:

- 0.5% of total range for a chart recorder. This translates to a 0.5" of water column error for a 100" chart, or a 1" of water column error for a 200" chart.
- 0.25% of total range for an electronic transducer coupled to a flow computer.

Because of these errors, measurement error is greater at low differential pressures. An orifice meter's advantage is inherent simplicity, no moving parts in the flow stream, a damaged orifice plate does not impede flow and an orifice plate is cheaper and easier to replace than turbine meter internals. Several configurations are available, from a simple set of orifice flanges to a dual-chambered orifice fitting accommodating orifice plate change-outs under pressure without interrupting flow.

The orifice meter's range ability is limited. For a given orifice size, range ability is 3:1 for a chart recorder or 4.5:1 for a differential transducer and flow computer. This limit makes it unsuitable in widely varying flow conditions (such as winter versus summer loads) without frequent orifice plate changes. Nevertheless, before the turbine meter, the orifice meter was the high pressure, high volume industry standard. It is still the only practical measurement method in a dirty gas environment such as a wellhead application. .

ii) Turbine Meters:

Turbine type gas meters have been manufactured since the early nineteen hundreds. Since the 1950s, they have been considered favorably for the measurement of large volume gas flows. The designs have proved receivable, accurate and repeatable.

Two basic assumptions relate to the operation of the turbine meter:

-The angular velocity of the rotor is proportional to the volumetric flow rate passing through the meter.

-The pulsed output frequency of the pick-up is proportional to angular velocity of the rotor.

The axial flow gas turbine meter comprises of three main components:

- The body through which the gas passes.

-A rotor with bearings and supporting structure.

-A device to transfer the internal revolutions of the rotor to an external counter.

Gas flowing through the meter impinges on turbine blades located centrally along the axis of the unit. Turbine blades are free to rotate, and do so in a manner directly proportional to the velocity of the gas passing the blades.

The area of the rotor face as defined by the mean radius of the rotor can be determined. Permanent magnets installed in the hub of the rotor, turn with the rotor to produce a magnetic field, which passes through a coil. As each of the magnets pass the coil, a separate and distinct voltage pulse is created. The frequency of these pulses is proportional to the velocity of the rotor is also proportional to the flow rate. Each pulse is also proportional to a small unit of volume. The pulses, the effective flow rate and total flow are transmitted by frequency and by counting the pulses. The output frequency has been conditioned into a square wave through a preamplifier. This conditioning allows it to be transferred to a remote flow computer. Each pulse represents only a small incremental volume of flow. Since the turbine meter measures volume at line conditions, the gas laws can be applied to change the register volume to base conditions.

The turbine meter has wide range ability (to 200:1 depending on meter size and line pressure), greater accuracy potential and more versatility in adding mechanical and electronic auxiliary devices. Like an orifice meter, a turbine meter does not impede flow if there is damage or failure. This is important when maintaining gas service to a downstream consumer is critical.

Applications:

The turbine meter is basically recommended for applications involving the measurement of clean gases. However, it can have limited applications for dirty gases. Turbine meters generally come in sizes ranging from nominal diameters of 50 mm to 600 mm, although larger sizes can exist. Operating temperature ranges are generally within the range of −10 ^{0}C to +50 ^{0} C. Some of the manufactures will provide meters with extended temperature ranges. Operating pressure ranges from 14.4 to 80 bars.

A number of factors must be considered when sizing a turbine meter for a given application. Turbine meters are sensitive to both gas viscosity and inlet flow profile. With the actual magnitude of the resulting degradation being a complex function of body geometry and blade shape. Generally the smaller meters are more viscosity sensitive, and they also do not have the range ability of the larger meters. This is due to bearing friction being proportionally higher since the bearing diameter is large compared to pipe diameter. It is usually good practice to have an appropriate upstream flow conditioner installed with a turbine meter system.

Advantages:

The advantages of a turbine meter flow measurement system are:

Excellent range ability on gas at high pressure
Malfunction will not cause gas flow to stop
Presents good accuracy over full linear range of meter
Electronic out put available directly at high resolutions
Has good pressure and temperature operating capabilities
Has legal metrology status for custody transfer applications
Cost of meter is medium, overall installation cost low to medium

Small weight to capacity ratio

Can be calibrated for actual operating conditions

Disadvantages:

- Viscosity affects liquid meters- may require separate calibration curves for different viscosity.
- Sensitive to upstream flow profiles.
- Calibration can be expensive

3.3 Quality features of Gas Meters

The main quality features of gas meter are load range, calibration, operation error limits, pressure loss, effective range and range ability.

Working flow rate range of the gas meter:

The range of flow rates is limited by the maximum flow rate, Q_{max} and the minimum flow rate, Q_{min}

3.3.1 Range ability (turndown ratio)

This is defined as the maximum flow divided by the minimum flow. The ratio indicates a meters capacity to measure volumes accurately for high variable loads.

3.3.2 Working pressure

The difference between the absolute pressure of the gas to be measured at the inlet of the gas volume meter and the atmospheric pressure is the working pressure.

3.3.3 Pressure loss (or pressure absorption)

The pressure loss is the difference between the pressures at the inlet and the outlet of the gas volume meter while the gas is flowing.

3.3.4 Error

The volume indicated by the gas meter minus the conventional true volume of the measured.

$E = V_i - V_c / V_c$

Where, V_i is the indicated volume and V_c is the conventional true volume.

3.4 Parameters for meter selection

No universal meter exists; each type possesses some limitations. Some meters may only be useful for specific applications, where as others can be widely adopted. It is necessary to consider not only from a measurement requirement, but also from economic, supply, security, safety and even customer confidence, that the correct meter is selected for the given application. Certain parameters must be tested against to ensure that the meter selection is optimal. Some of these parameters are:

a) The maximum and minimum flow rate.

b) The extremes of pressure and temperature at measurement conditions.

c) The ranges of chemical and physical properties of the fluid.

d) Duration of operation of the meter (operating continually, for only a few hours per day/ week, or intermittently).

e) The consequences of the gas flow being stopped by meter malfunction (Whether the end user of the fluid being measured has an alternative source of supply/ Whether fluid stoppage present a hazard or result in significant production loss etc).

f) Available space for the installation of such meters (For example, the number of pipe straight lengths required upstream and downstream of the meter)

g) The economic consequence of uncertainties in the measurement (Expectation of the customer as to the accuracy of the fluid measurement).

h) The legal metrology requirements (Ease of calibration etc)

i) Whether the meter is cost effective.

3.5 Meters used by TGTDCL

TGTDCL has a large customer base of different nature of customers from a low gas load domestic customers to bulk customers like power plants and fertilizer factories, which consume a very large amount of gas. Positive displacement meters are used for domestic and commercial customers, which require small quantity of gas at low operating pressure. Usually rotary meters are used for industrial customers (up to 450m^3/ hr). The following meters are used by TGTDCL.

-Diaphragm Displacement Meters

-Rotary Displacement Meters

-Turbine Meters

-Orifice Meter

3.6 Selecting Meters:

Table 3.4 shows common meters used in measurement applications. It is not all inclusive and applications are generic examples for illustrating rather than defining pressure and load ranges indicated. It is not feasible to be more specific about the meter size to use since meter capacity varies greatly with operating pressure. It is required to consult the manufacturers' catalogues for actual meter capacities.

The type of meter output needed by the desired flow corrector must be decided early in any project. Meter output can be mechanical and/or electronic. Mechanically, one turn of the meter's output drive shaft represents a precisely known gas volume at line conditions. Electronically, the output consists of a frequency proportional to gas volume at line conditions.

An electronic output is required for flow computers and the supervisory control and data acquisition (SCADA) system. Typically, diaphragm, rotary and smaller turbine meters are only equipped with mechanical outputs. Large turbine meters have both mechanical and electronic outputs.

Table-3.4: 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

3.7 Concluding Remarks of the Chapter

Most common types of flow meters used universally on natural gas transmission systems have been discussed hereto. The most common gas meters are the diaphragm or positive displacement meters, as used for domestic gas meters and small commercial and industrial application. This type of meter is robust, cheap and has good range ability and prolonged life; however it has limited high-pressure capability and is not available with high capacities. It is likely the orifice plate meter and turbine meter will maintain their status for some time. The orifice plate meter is slowly yielding to the turbine meter and the more recently introduced non-intrusive meters.

Although a variety of alternative volume metering systems are available, only probably one is mounting a serious challenge to these established gas flow meters. This meter is the ultrasonic meter; however it should be acknowledge that the vortex meter has also gained substantial popularity in some countries, but not universally. There is still considerable effort, particularly in North America and Europe, being devoted to the better understanding of the orifice plate turbine meter, including enhancement in traceability chains and calibration procedures.

CHAPTER 4: OVERVIEW OF THE GAS PRE-PAID METERING SYSTEM

TGTDCL has installed 1000 gas pre-paid meters for domestic customers on a trial basis. Three main components are gas pre-paid meters, IC cards, and Gas selling management. Technical specifications of gas pre-paid meters, IC card (smart card) and Gas selling management are described in this chapter. The specifications are provided by TGTDCL as described in the bid documents for supply, installation, testing and commissioning of 1000 domestic pre paid meters (Ref: Bid document-Titas/PD/2312/pre paid meter/2004, dated – 04/11/04).

4.1 Technical Specification for Pre-Paid Gas Meter

4.1.1 This positive displacement type of gas meter is used for the measurement of Sweet Natural Gas having Molecular Weight-17.3, Specific Gravity-0.6 (air = 1.0), and water content not more than 7lbs/MMSCF and condensate not more than 2 US gallons per MMSCF. It would meet the following operating conditions and requirements-

Reference Standards:

The following international standards would be maintained-

(a)	OIMLR31	-	1995
(b)	BG/T6968	-	1997
(c)	CJ/T112	-	2000

Operating Conditions:

a.	Maximum Working Pressure	-	300 mbarg (for G1.6 to G 2.5)
b.	Operating Pressure	-	200 mbarg to 30 mbarg.
c.	Operating Temperature	-	0^0C to 50^0 C
d.	Total pressure loss	-	2 mbarg (Mas.).
e.	Relative Humidity	-	98% at 30^0C
f.	Permissible error	-	a. Qmin $\leq$ Q $\leq$ 0.1 Qmax =+3% Qmax $\leq$ Q $\leq$ 0.1 Qmax =+3% b. Repeatability: 0.1% or better
g.	Turn down Ratio	-	100: 1

4.1.2	Meter Capacity Range	-	G-1.6 to G-2.5 (Badged) refers to 2.5 M^3/hr to 4.0 M^3/hr.
4.1.3	Environment Status:	-	Safe Guard to be provided with the meter IP-67
4.1.4	Intrinsic Safety:	-	EEx in IIA T3 or any other relevant International code.
4.1.5	Security Sealing:	-	Index and other parts where necessary shall properly be sealed with lead or other suitable material embossed with manufacturers trade mark to prevent any unauthorized tampering.
4.1.6	Connections Size:	-	Inlet and outlet connection size will be ¾"× ¾" Male NPT threaded with female union/ swivel.
4.1.7	Automatic Control Function	-	Turning on/off gas supply valve according to the situation of prepayment storage and gas consumption, shall be automatic
4.1.8	Card Reader	-	The meter shall have the IC Card reader device (IC-Chip) with high resistant to magnetic interference.
4.1.9	On-time calculation Function:-		On-time calculation and display of the balance amount left.

4.1.10 Material Requirements

(a)	Body/Case Materials	-	Die-Cast Aluminum
(b)	Diaphragm Material	-	Synthetic material having with standing capability to handle the fluid mentioned above.
(c)	Spud connection Material:	-	Shall conform to the appropriate material in line with the body/case material.

4.1.11 Configuration of the Meter Body

(a) Body halves must be folded to form hermetically sealed joint at its halves.

(b) It should have tow top entry pipe connection.

(c) Meter body should be properly sealed to make it tamper proof.

(d) Fire safe design to be maintained as per applicable international code.

4.1.12 Index

(a) Mechanical counter type, direct reading in M^3 as per OIML-R-31 (latest version) recommendations.

(b) All of the extreme right digits after the decimal point should be provided with the light barrier point/ dots to test the meter accuracy at the computerized calibration bench.

(c) LCD display: To display the information of the IC card, message and others.

(d) Index Box: To be secured and sealed against any illegal access.

(e) Back Stop device: It must have a device that prevents the reverse flow of gas.

4.1.13 IC Chip

(a) The meter should accept the IC Pre-paid Card.

(b) The IC Chip will generate alarm and make the system in operative to protect it from pre-set minimum and maximum gas flow rate.

(c) It will store accumulated consumed gas, last prepaid volume, volume of gas as a balance left, card number, meter number etc.

(d) Once after inserting the IC Pre-paid Card, one can start use of gas. It will take the total volume of gas and then the card would be disposed off.

(e) Once the meter runs out of gas (or the IC Chip has no amount left), the valve shall be closed instantly to stop the flow of gas.

(f) The IC card cannot be pulled out until the storage of card-value. After completion of storage the IC card-value it would be ejected automatically.

(g) When the remaining volume is less than $6m^3$ (six meter cube), the meter will give alarm to indicate that there is not enough volume of gas left. Whenever at this critical limited, the customer uses further gas, the meter will give alarm for each 1 (One) m^3 and for every 0.1 m^3 interval for the last cubic meter left.

(h) In case of illegal gas use or meter bypassing the gas flow will be stopped automatically.

(i) The meter will have outlet pressure sensor- if the meter is dismantled, the motor valve inside the meter will be closed automatically and store the record in the meter. The meter would not be reusable without the help of Gas Company personnel.

(j) Automatically adjust the unit price in accordance with the Pre-paid Card.

(k) Multiprogramming & encryption technique.

(l) Voltage sensitivity- for lower voltage the function of valve closes.

(m) Storing capacity is 300 SM^3 of gas.

(n) Over pressure protection.

4.1.14 Power supply:

(a) Battery operated. 1AA Lithium/Mn or 4AA Alkaline batteries.

(b) Service life: 10 years.

(c) Battery life≥ 5 years.

4.1.15 Display Facility

The LCD of the meter shall display some indicating information/message for the following situations:

(a) When the new gas meter is not preset by gas Supply Company.

(b) When IC card is under reading mode my micro- controller.

(c) When ending of new meter setting.

(d) When the volume residual in the meter card reaches the maximum limit as specified by the Gas supply company.

(e) Alarm of low-voltage of battery, indicating replacement of battery.

(f) When IC card is damaged.

(g) Insertion of illegal card.

(h) At the time of pulling of the card prior to readout of the card by the controller.

(i) Non-completion of card reading by the controller.

(j) Mistake in checking the user-card.

(k) Before closing the valve.

(l) Remaining Credit in Taka Continuously.

(m) When the meter is installed the gas control valve shall be closed and LCD will show "0000"

4.2 Technical Specification of IC-Card/Smart Card

IC card is the main component of a pre paid gas metering system. Various data are stored in the IC card (for example-remaining gas amount, balanced taka etc.).

4.2.1 General

The technical/other parameters of the IC-Card/Smart Card should be as follows

a) Reference standard should be ISO 7816-3 Synchronous Protocol.

b) Answer-t- Reset Register.

c) High Security Memory Including Anti-wire Tapping.

d) Authentication Protocol.

e) Authentication Attempts Counter.

f) Specific Passwords for Read and Write.

g) Password Attempts Counters.

h) Selectable Access Rights by Zone.

i) ISO Compliant Packaging.

j) High Reliability.

k) Low-Power CMOS.

l) Low Voltage Operation: 2.7V to 5.5 V.D.C

4.2.2 Primarily the IC Card/Smart Card will be blank and after vending it will contain fixed amount/volume of gas.

4.2.3 The identity of the vending operator is stored.

4.2.4 It should be scratch proof as well as high magnetic interference proof.

4.2.5 The data storing and resume the function.

4.2.6 Type of Card

IC Card/Smart Card should be designed & supplied by the bidder as per purchasers requirements and efficient running of the system.

4.3. Gas Selling Management System (GSMS)

4.3.1 Basic Description

It is a complete package comprising of a computer being associated with a software (Menu driven), vending machine and others. It shall be able to configure the IC Card to its parameters but not limited to those mentioned in Para 4.2 (IC-Card). Vending machine is a machine, which can write and rewrite in an IC card. It can also read the information (Card ID, Date of generation of the card, Previous balance amount in the meter during card charging, amount of gas that remains in the card etc) of the card. It is driver/ software operated device whose features are controlled by the main SGMS software.

4.3.1.1 Purchasing Credit

The system must have a provision for the customers to purchase credit as fixed by the Gas Company.

4.3.1.2 Credit removal:

It shall have a provision for removal of the credit from a customer token in case of error.

4.3.1.3 Credit Receipt

The point sales (POS) terminal shall provide a receipt of each transaction in paper form. An electronic record of each transaction shall be taken and recorded in the internal memory of the terminal.

4.3.1.4 Tariff

It must have a provision for adjustment in the change of Tariff, as and when it is deemed to revise on a specified time and date.

4.3.2. System Security (Between the operator and the system administrator):

4.3.2.1 Security General

The system to be provided shall be secured both in terms of the cash transacted through the system and the data collected and managed by the system. The system shall offer more than one level of physical security distinguishing between operators and system management staff.

4.3.2.2 Operator Security

The system must be capable of allocating security on an "operator by operator" basis. That is, it must be possible to create a specific user menu (Name, Passport etc.) for each operator.

4.3.2.3 Security of cash transactions

All cash transactions must be recorded and simultaneously an electronic record shall also be made of each transaction. It must not be possible to amend the transaction file at the operator level of the system.

4.3.2.4 Point of sales terminal security

Vending terminals must be restricted to the granting of credit with operator security only. The unit must be protected from removal by the provision of a physical security key. Operation of the unit will not be possible unless the security device (correctly ceded) is pre-set.

4.3.2.5 Physical Security

The point of sales terminal shall require an encryption key in order to operate. The encryption key is to be stored on a device, which can be removed from the point of sales terminal during the time when it is not in use.

4.3.3 Gas Consumption Charges

Charges shall be counted in the form of "TAKA" based on the charge rate i.e. Tariff (@Tk. /- per standard Cubic meter of gas).

4.3.4 Accuracy

The system shall deal with all monetary calculations in absolute terms. The meter will deduct charges for consumption in accordance with, and to the level of accuracy specified in the active tariff.

4.3.5 Central Management System (CMS)

4.3.5.1 General

The management system element shall be responsible for the collection of electronic transaction information forms the point of Sales terminals. Collection must be enabled using standard LAN System, with the option for disk transfer in the case of system failure.

4.3.5.2 PC specification

In order to reduce maintenance costs and to minimize training, the System Management unit shall be based upon a standard PC running either the Windows NT/XP or higher version operating system. All software used, at both the Master and Point of sales levels must be menu driven.

4.3.5.3 Data Format

The data collected by the system will be available in a defined standard format for data exchange.

The system management element will be capable of producing floppy disks containing the electronic transaction information for all of the vending elements in the system in a consolidated format.

4.3.5.4 Hardware/Software

The Bidder should supply and install a server with associated Software. The Gas Company will give the details customer's information to the Bidder and the Bidder should have to customize the software as required by the Purchaser. The Bidder should also configure the point of sales (POS) terminals i.e. Dealers Systems as deemed necessary by the Purchaser. The Software must contain the following Data base information.

a) Dealer Record with code No.
b) Detail customer information (Customer ID, Meter No.), date of meter installation, used Gas Volume, Disconnection date, No. of Burners, first connection date etc.
c) Customer complains center and IC-Card purchase date.
d) Hardware should be compatible to Pentium III (Three), Pentium IV (Four), or higher version of being commercially recognized PC or Lap Top computer. All the PC's should be IBM compatible and branded one.

4.3.5.5 Data Backup and Restoration

The system must have a provision for the regular back up of data. In case of power failure to the system, all data must be saved into a primary back-up facility. On power-up, the system is to automatically restore the system to that which pertained immediately prior to the power outage with no loss of data.

4.3.5.6 Point of Sales (POS) / Distributor

The individual Gas Company will appoint the distributor to sell the IC-Card to the customers. The distributor/Sales Centre should have on line computerized system. They will sell charged IC-Card/Smart Card to a customer and send all the records to the central server computer through online. No end operator software required in this case.

4.3.5.7 Database Structure.

The proposed database structure should be

a) Oracle/Sybase/SQL database.
b) Domain based web server with extensive band with (Totally dedicated for the Gas Marketing Company).
c) Database integration to acting dynamic script base languages such as ASP, JSP, Perl, PHP.
d) Server side software resides only in server.

4.3.5.8 Management Menu

The Selling Gas management System Software (SGMS) for both vending machine and central computer/server will have the management menu on all the information specified by the Gas Company.

The Management menu shall cover minimum the following:

a) Main Menu for Financial trends to be investigated, Audit analysis, Sales volume treads to be investigated etc.
b) Dealers/Point of Sales (POS) terminal details, additionally including group/area or district massage.
c) Consumers Menu of Meter details, Customers details, Payment details, additional function.
d) Consumers Receipt Menu.
e) Engineering Menu.
f) Tariff and Tax Rate Menu.
g) Customers complain centre.
h) Reports Menu.

4.4. Calibration and testing of meters

Meters were tested in Demra workshop before installation. The test result showed no problems in meters at that time but the actual problems occurred while the meters were in operation for a few months. After the defects found by a thorough inspection by TGTDCL representatives, some randomly selected meters were sent to Institute of Information and Communication Technology (IICT), BUET. Their major findings were as follows:

- The calibration of the meters was not accurate.
- The quality of the used materials for electronic module was poor.
- Power supply system of the meter was of lower quality.
- LCD display was of poor quality.

CHAPTER 5: RESULTS FROM THE PILOT PROJECT

Out of 1000 pre-paid domestic gas customers, 848 customers have been surveyed. Some customers were surveyed as a routine work. Some customers complained regarding various aspects such as display problems, meter non-functioning, gas supply problems etc. On the basis of those complains customers were inspected. Some customers were inspected by the author for the study. Out of these, 103 owners were not available. Data have been collected on the said customers regarding different technical faults. Billing status of pre-paid customers and comparison of bills on pre-paid base with flat rate base has been incorporated in this chapter. Statistics between difference of analogue and digital readings, customers' feedback are also included. Information gathered from the surveys and inspections are compiled and presented in results.

5.1 Inspection Results

848 residential pre-paid customers have been visited for collecting data regarding different parameters such as flow condition, verification of any technical fault, customers' feedback etc. Out of visited customers, some were not available; some refused to allow inspection, while some other were staying abroad. Statistics of these are shown in the following table.

Table- 5.1: Inspection Data of Existing Gas Pre- Paid Meters

Visited	848
Owner not available	103
Nobody resides	26
Refused to allow inspection	13
Staying abroad	8

The inspected customers fall into three categories the numbers of which are shown in the table-5.2

Table- 5.2: Category of the inspected Existing Gas Pre- Paid Customers

Home	718
Office	94
Foreigner	36
Total	848

5.2 Problems Occurred In Meters

From the inspected pre-paid customers, some faults have been identified. The customers have been inspected as a routine work. In some cases customers have reported about malfunction of pre-paid meters. Total numbers of faulty meters were 503. Some meters have single problem such as consumption error or battery damage or charging problem etc. Some meters have two or three combined problems such as consumption error plus battery damage or consumption error plus battery damage plus charging problem. etc. Types of faults that were detected are shown in the table- 5.3

Table- 5.3: Technical faults found in the Meters

Fault Type	Fault Count
Consumption Error (Difference between analogue and digital reading)	375
Battery Damaged	45
Meter Damaged	18
Negative Digital Reading	4
Display Damaged	6
Meter Lock	112
Card Charging In Meter	178
Total	738

From the above table it is clear that consumption error is the highest among the different types of faults. Significant number of faults also occurs due to card charging problems and meter lock

Readings have been collected from the inspected pre-paid meters. A variation occurs between analogue and digital readings. A large consumption error (the difference between analogue and digital readings) occurs in 375 meters.

Analogue reading : 94,740.89 m^3

Digital reading : 53,421.12 m^3

Difference between Analogue and Digital reading : 41,319.77 m^3

Percentage Difference : - 43.61%

In some existing pre-paid meters, irregular activities were detected that are shown in the following table-5.4.

Table- 5.4: Irregular activities found in the Existing Gas Pre- Paid Meters

Category of irregularities	Quantity
Meter By Pass	6
No Seal In Meter	10
Total	16

5.3 Custumer feedback

Other data regarding customers' satisfaction and dissatisfaction have been collected. Some customers are satisfied who commented that their bills have been reduced in regard to flat rate billing. They also advocated the billing system on actual consumption. The customers who were dissatisfied about the pre paid metering said that meters have some problems such as locking, battery damage etc. Customer feedback is shown in the table-5.5.

Table 5.5: Customer feedback

Overall Assessment	No of Customers	Percentage of Customers
Satisfied	162	19.10%
Not Satisfied	122	14.39%
Indifferent To Comment	564	66.51%
Total	848	100.00%

The above table reveals that most of the customers are indifferent to comments (neither satisfied nor dissatisfied). More number of customers are satisfied compared to dissatisfied customers regarding domestic gas pre paid metering system.

5.4 Financial Statement

Revenues earned by selling pre-paid and the revenues to be earned on the flat rate basis have been shown in the table-5.6.

Table- 5.6: Revenue summary on pre-paid card basis compared to flat rate billing (Oct 05 to April 06)

Month	Cards Sold (Taka)	Bill On Flat Rate Basis (Taka)
October 05	2,15,200.00	4,42,010.00
November 05	1,68,000.00	4,42,010.00
December 05	1.90,400.00	4,42,010.00
January 06	2,13,203.00	4,42,010.00
February 06	1,62,200.00	4,42,010.00
March 06	1,70,800.00	4,42,010.00
April 06	1,91,400.00	4,42,010.00
Total	13,11,203.00	3,09,4070.00
Percentage Difference	- 57.62%	

The above table shows that due to the billing system under the gas pre paid metering pilot project bill or revenue have been decreased compared to flat rate bill. The metered bill is 57.62% less than the flat rate bill. The probable reasons include error in digital reading (consumption error), stoppage of unnecessary wastage of gas for installation of meters.

CHAPTER -6: FINANCIAL ANALYSIS OF GAS PRE-PAID METERING PILOT PROJECT

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).

6.1 Sustainability Analysis

Sustainability refers to the ability of the project to continue. Identification of resources needed and their use will depend on operational requirement. Sources of financing may be public, private, or beneficiary community. Sustainability and cost effectiveness are not synonymous; however, one way to attain sustainability is to improve cost effectiveness. As a process, sustainability takes into consideration both cost and benefit issues.

Sustainability should be viewed from both demand and supply aspects. On the demand side sustainability relates the need and acceptance of the project by the clientele. It includes beneficiary's willingness and ability to pay directly or indirectly for the services or benefits they derive from the project. On the other hand, supply side indicates the extent to which the project can afford to provide benefits or services.

Costs saving through improvement in the management system and revenue earnings through community financing scheme are perhaps the two approaches an organization can follow to become sustainable. Both approaches help reduce an organization's risk of disruption in continuing project implementation, should funding be reduced or stopped. Sustainability is a gradual process; careful planning is needed regarding strategy or strategies to be pursued at different phases.

6.2 Calculations and Results

The analysis is made for a group of 10,000 pre-paid meters for 10,000 domestic customers. The following sequential analysis is done.

A. Investment Cost		
Sl No	Particulars	Amount in $
1	Meter price @ $80 for each meter (10,000 meters)	8,00,000.00
2	Pipe line and accessories	1,20,000.00
3	Installation cost	1,20,000.00
4	Server and POS terminal equipment with SGMS	13,530.00
5	POS office setup	8,571.43
6	IC card cost	4,000.00
7	Training of Titas personnel	2,500.00
8	Vehicle	50,000.00
9	Total	1,118,601.43
B. Operating Cost (Annual)		
1	Services and maintenance	22,372.02 (2% of the Investment cost)
2	Utility expenses	2,000.00
3	Rent	20,000.00
4	Salaries and wages	40,000.00
5	Administrative overhead	10,000.00
6	Total	94,372.02

Break –up of the expenses for items described in A & B are given below.

Utility expenses is assumed to be Tk.1.40,000 or $ 2000 annually. Rent for office for the project is Tk.14 lac or $20,000. Administrative overhead of the project is Tk. 700000 or $ 10000 annually or monthly Tk. 50,000. Average salary of 40 people to be engaged for running the project is $1000 or TK. 70,000 annually.

Pipe line and accessories cost :

Pipe= 20' per customer.
Cost= Tk. 20x 36 = Tk.720
Fitting (Elbow + Socket)= Tk.30
Valve= Tk. 100
Total= Tk. 850=$ 12
Cost of server and POS terminal equipment with SGMS

5 Nos. of Vending machine (VM) @ $ 296	$	1,480.00
1 No of server	$	4,700.00
5 Nos of workstations @ $ 1050	$	5,250.00
1 No. Server UPS	$	250.00
5 Nos workstations UPS @ 2000	$	1,000.00
Printer 2 No (with software)	$	850.00
Total	$	13,530.00

Training cost of Titas personnel

(a) Installation / Operation/ Maintenance and Trouble shooting	(6 persons x 10 wks)	
(b) Data entry operator	(8 persons x 5 weeks)	$ 2500
(c) Data Base Administrator	(2 persons x 6 wks)	
(d) Gas selling management system	(2 persons x 5 wks)	

Vehicle Cost:

4 Pick up @ 12,500 = $ 50,000

C. Cash inflow

Estimated gas sale through each meter	1,455.71 CM Per year
Estimated gas sale through 10000 meter	1,45,57,110.78 CM Per year
Revenue margin for the distribution @ 0.0101571/CM	$1,47,858.03
Meter rent collected annually from 10,000Nos	$1,27,809.18
Total Cash in flow for the first year	**$2,75,667.21**

Cash inflow Analysis (Calculation Details):

Estimated gas sale through each meter = 21 cft / hr

$$= \frac{21 \times 8 \times 30 \times .85}{35.3147} \ m^3 / \text{month}$$

$$= 121.309 \ m^3 / \text{month}$$

Operational/ utilization pattern (Assumed operational pattern of TGTDCL for domestic customers):
8 hrs / day, 30 days / month, diversity factor = 0.85

Annual gas sale through each meter = 121.309 x 12

$= 1455.711078 \ m^3$

Annual gas sales through 10000 meter $= 14557110.78 \ m^3$

Revenue margin for the distributor @ $ $= 0.0101571 / m^3$

Revenue earned from gas sales through 10,000 meters

= $ 0.0101571 x 14557110.78

= 147858.03

Meter cost $ 800000 is amortized in 20 years. Considering the interest rate of 15%, amortization table (Appendix-B)) shows that Meter rent collected annually is $ 127809.18 (except the last (20^{th}) years.

The total revenue collected for the first year = $ (147858.03+127809.18)
= $ 275667.21

Net cash flows need to be converted into present values.

$PV=FV/(1+i)^n$

Where, PV = Present value

FV= Future value

i = Discount rate

n= No of years

$\frac{1}{(1+i)^n}$ = present worth factor = Discount factor

Now, depending on the discount rate (i), present worth factor will be different

For example, present worth factor at a discount rate of 15% for different future value are as follows:

For year 0: present worth factor = $\frac{1}{(1.15)^0} = 1$

For year 1: present worth factor = $\frac{1}{1.15} = 0.869565$

For year 2: present worth factor = = 0.756144

In this way finding discount factor future values can be turned in to present value the table shows different present values of future cash flows.

$$\sum PV \text{ inflow} = \frac{FV_1}{1+i} + \frac{FV_2}{(1+i)^2} + \frac{FV_3}{(1+i)^3} + \text{------------} + FV^n/(1+i)^n$$

at 15% discount rate

$$\sum PV \text{ inflow} = \frac{18129.18}{1.15} + \frac{186800.64}{1(.15)^2} + \ldots\ldots\ldots + \frac{347286.06}{(1.15)^{20}}$$

= 1377828.99

6.2.1 Calculating NPV

NPV = ∑PV cash in flow – ∑PV cash out flow

= 1377828.99-1118601.93

= 259227.56

NPV at 15% dr = 259227.56

Similarly different NPV can be calculated at different discount rate. In the table (Table-6.1) NPV at other discount rates of 10%, 20%, 25% ad 30% are shown which are respectively $ 838807.87, -$ 83127.40, -$ 300059.89 and $ -446132.85

Table-6.1:Cash flows and NPV at different discount rate

Year	Total cash out flow	Cash in flow from gas sales	Cash Inflow from meter rent	Net cash flow(B-C+D)	Present value at various discount rate					
					10%		15%		20%	
					Present worth factor	Present value	Present worth factor	Present value	Present worth factor	Present value
0	-$1,118,601.43	$0.00		-$1,118,601.43	1	-$1,118,601.43	1	-$1,118,601.43	1	-$1,118,601.43
1	-$94,372.03	$147,858.03	$127,809.18	$181,295.18	0.90909	$164,813.80	0.86957	$157,647.98	0.83333	$151,079.32
2	-$96,259.47	$155,250.93	$127,809.18	$186,800.64	0.82645	$154,380.70	0.75614	$141,248.12	0.69444	$129,722.67
3	-$98,184.66	$163,013.48	$127,809.18	$192,638.00	0.75131	$144,731.78	0.65752	$126,662.61	0.5787	$111,480.32
4	-$100,148.35	$171,164.15	$127,809.18	$198,824.98	0.68301	$135,800.14	0.57175	$113,678.83	0.48225	$95,883.96
5	-$102,151.32	$179,722.36	$127,809.18	$205,380.22	0.62092	$127,524.98	0.49718	$102,110.27	0.40188	$82,537.70
6	-$104,194.35	$188,708.48	$127,809.18	$212,323.31	0.56447	$119,850.97	0.43233	$91,793.23	0.3349	$71,106.65
7	-$106,278.23	$198,143.90	$127,809.18	$219,674.85	0.51316	$112,727.93	0.37594	$82,583.91	0.27908	$61,307.22
8	-$108,403.80	$208,051.10	$127,809.18	$227,456.48	0.46651	$106,110.13	0.3269	$74,355.83	0.23257	$52,899.11
9	-$110,571.87	$218,453.65	$127,809.18	$235,690.96	0.4241	$99,955.97	0.28426	$66,998.08	0.19381	$45,678.49
10	-$112,783.31	$229,376.33	$127,809.18	$244,402.20	0.38554	$94,227.63	0.24718	$60,412.49	0.16151	$39,472.32
11	-$115,038.98	$240,845.15	$127,809.18	$253,615.35	0.35049	$88,890.63	0.21494	$54,512.90	0.13459	$34,133.58
12	-$117,339.76	$252,887.41	$127,809.18	$263,356.83	0.31863	$83,913.80	0.18691	$49,223.28	0.11216	$29,537.22
13	-$119,686.55	$265,531.78	$127,809.18	$273,654.41	0.28966	$79,267.93	0.16253	$44,478.49	0.09346	$25,576.80
14	-$122,080.28	$278,808.37	$127,809.18	$284,537.27	0.26333	$74,927.56	0.14133	$40,213.27	0.07789	$22,161.63
15	-$124,521.89	$292,748.79	$127,809.18	$296,036.08	0.23939	$70,868.63	0.12289	$36,381.20	0.06491	$19,214.36
16	-$127,012.33	$307,386.23	$127,809.18	$308,183.08	0.21763	$67,069.62	0.10686	$32,933.91	0.05409	$16,668.97
17	-$129,552.57	$322,755.54	$127,809.18	$321,012.14	0.19784	$63,510.54	0.09293	$29,830.34	0.04507	$14,469.08
18	-$132,143.62	$338,893.31	$127,809.18	$334,556.87	0.17986	$60,173.35	0.08081	$27,034.07	0.03756	$12,566.38
19	-$134,786.50	$355,837.98	$127,809.18	$348,860.66	0.16351	$57,041.51	0.07027	$24,512.81	0.0313	$10,919.64
20	-$137,482.23	$373,629.88	$111,138.41	$347,296.06	0.14864	$51,621.86	0.0611	$21,219.28	0.02608	$9,058.63
		NPV				$838,807.87		$259,227.58		-$83,127.40

6.2.2 Calculating IRR

IRR is calculated as follows :

$$\frac{r_b - r^*}{r_b - r_a} = \frac{NPV_b}{NPV_b - NPV_a}$$

NPV_a = positive NPV at the tower discount rate of 15% (ra)

= $ 259227.56

NPV_b = Negative NPV at the higher discount rate of 20% (rb)

= $ 83127.40

$$r^* = IRR = r_a + (r_b - r_a) \times \frac{NPV_a}{NPVa - NPV_b}$$

$$= 0.15 + (0.2 - 0.15) \times \frac{259227.56}{342354.96}$$

= 189 = 18.9% = 19%

IRR = 19 %

6.2.3 Calculating profitability index (PI) or Benefit –cost ratio (BCR)

The benefit-cost ratio (BCR) or profitability index (PI) is defined as the ratio of the present value of an investment's future cash inflows and the present value of its cost. BCR or PI of this project is calculated in the table- 6.2.

Table-6.2: DCR /PI Calculation

Year	Total cash out flow	Cash in flow from gas sales	Cash inflow from meter rent	Total cash Inflow(C+D)	Present value of cash out flows and inflows at 15% discount rate		
					Present worth factor	Present value of cash outflows	Present value of cash Inflows
0	-$1,118 601 43	$0 00		$0 00	1	-$1,118,601 43	$0 00
1	-$94 377 03	$147,858 03	$127,809,18	$275,867,21	0 86957	-$82,062 63	$239,710 62
2	-$96,259 47	$155,250 93	$127,809 18	$283,060 11	0 75614	-$72,785 99	$214,034 11
3	-$98,184 66	$163,013 48	$127,809 18	$290,822 66	0 65752	-$64,558 01	$191,220 62
4	-$100,148 35	$171,164 15	$127,809 18	$298,973 33	0 57175	-$57,260 15	$170,938 97
5	-$102,151 32	$179,722 36	$127,809 18	$307,531 54	0 49718	-$50,787 28	$152,897 53
6	-$104,194 35	$188,708 48	$127,809 18	$316,517 66	0 43233	-$45,046 09	$136,839 32
7	-$106,278 23	$198 143 90	$127,809 18	$325,953 08	0 37594	-$39,953 92	$122,537 84
8	-$108,403 80	$208 051.10	$127,809 18	$335,860 28	0 3269	-$35,437 39	$109,793 32
9	-$110,571 87	$218 453 65	$127,809 18	$346,262 83	0 28426	-$31,431 43	$98,429 51
10	-$112,783 31	$229 370 33	$127.809 18	$357,186 51	0 24718	-$27,878 31	$88,290 80
11	-$115,038 98	$240,845 15	$127,809 18	$368,654 33	0 21494	-$24,726 85	$79 238 75
12	-$117,339 76	$252,887 41	$127,809 18	$380,696,59	0 18691	-$21,931 64	$71,154 91
13	-$119,686 55	$265 531 78	$127,809 18	$393,340 96	0 16253	-$19,452 41	$63 928 90
14	-$122,080 28	$278,808 37	$127,809 18	$406,617 55	0,14133	-$17,253 44	$57,486 71
15	-$124,521 89	$292,748 79	$127,809 18	$420,557,97	0 12289	-$15 303 05	$51,684 25
16	-$127,012 33	$307,386 23	$127,809 18	$435,195,41	0 10686	-$13,573,14	$46,507.06
17	-$129,552,57	$322,755 54	$127,809 18	$450,564 72	0 09293	-$12,038 79	$41,869 13
18	-$132,143 62	$338,893 31	$127,809 18	$466,702 49	0 08081	-$10,677 68	$37,711,95
19	-$134,786 50	$355,837 98	$127,809,18	$483,647 16	0 07027	-$9,470 82	$33,983 62
20	-$137,482 23	$373,629 88	$111,138 41	$484,768 29	0 0611	-$8 400 20	$29,619 48
					Total	-$1,778,630 83	$2,037,858.39
	BCR	1 14575					

6.2.4 Calculating pay back period

The amount of time required to recover the initial investment is the pay back period. If the future cash flows are not discounted to calculate pay back period then it is called normal pay back period. But when future cash flows are discounted at an appropriate discount rate, then the required time to recover the initial investment is called discounted pay back period.

Initial Investment = $ 1118601.43.

The table 6.3 is used to calculate pay back period and discounted pay back period.

Table-6.3: Pay back period & discounted pay back period Calculation

Year	Cash Flow		Accumulated cash flow	
	Undiscounted ($)	Discounted (At required rate of 15%) ($)	Undiscounted ($)	Discounted (At required rate of 15%) ($)
1	181295.18	157647.98	181295.18	8157647.98
2	186800.64	15141248.12	368095.82	298896.1
3	192638.00	126662.61	560733.82	425558.71
4	198824.98	113678.83	759558.80	539237.54
5	202380.22	102110.27	964939.02	641347.81
6	212323.31	91793.23	1177262.33	733141.04
7	219674.85	82583.91	13966937.18	815724.
8	227456.48	74355.93	1624393.66	890080.88
9	235690.96	66998.08	1860084.62	957078.96
10	244402.20	60412.49	2104486.82	1017491.45
11	253615.35	54512.90	2358102.17	1072004.35
12	263356.83	49223.28	2621459.00	1121227.63
13	273654.41	44476.49	2895113.41	1165704.12

From the table, it is clear normal pay back period is greater than 5 years but less than 6 years

$$\text{Pay back period} = 5 + \frac{(1118601.43-964939.02)}{(1177262.33-964939.02)} \text{ years}$$

$$= 5 + \frac{153662.41}{212323.31}$$

$$= 5.72 \text{ years}$$

From discounted accumulated cash flow column it is seen that the initial investment is recovered or get our bait back between 11 and 12 years.

$$\text{Discounted pay back period} \quad = \quad 11 + \frac{(1118601.43-1072004.35)}{(1121227.63-1072004.35)}$$

$$= 11+\frac{46597.08}{49223.28}$$

$$= 11.947 \text{ years}$$

6.2.5 Calculating Average Accounting Return(AAR)

AAR is a financial indicator, which is defined as the ratio of average net income and average book value. AAR is calculated in the table- 6.4.

Table-6.4: AAR calculation

Year	Expenses	Cash In flow gas sales	Cash inflow from meter rent	Total Revenue(C+D)	EBD(E+B)	Depreciation	NP/NI	Avg Net Income
1	-$94,372 03	$147,858 03	$127,809 18	$275,667.21	$181,295 18	$55,930 07	$125,365 11	
2	-$96,259 47	$155,750 93	$127,809 18	$283,060 11	$186,800 64	$55,930 07	$130,870 57	
3	-$98,184 66	$163,013 48	$127,809 18	$290,822 66	$192,638 00	$55,930 07	$136,707.93	
4	-$100,148 35	$171,164.15	$127,809 18	$298,973 33	$198,824 98	$55,930 07	$142,894 91	
5	-$102,151.32	$179,722 36	$127,809 18	$307,531.54	$205,380 22	$55,930 07	$149,450 15	
6	-$104,194.35	$188,708 48	$127,809 18	$316,517.66	$212,323 31	$55,930 07	$156,393 24	
7	-$106,276.23	$198,143 90	$127,809 18	$325,953 08	$219,674 85	$55,930 07	$163,744.78	
8	-$108,403 80	$208,051.10	$127,809 18	$335,860 28	$227,456 48	$55,930 07	$171,526 41	
9	-$110,571 87	$218,453 65	$127,809 18	$346,262 83	$235,690 96	$55,930 07	$179,760 89	
10	-$112,783 31	$229,376 33	$127,809 18	$357,185.51	$244,402 20	$55,930 07	$188,472.13	
11	-$115,038 98	$240,845 15	$127,809 18	$368,654 33	$253,615 35	$55,930 07	$197,685 28	$200,649 31
12	-$117,339.76	$252,887.41	$127,809.18	$380,696 59	$263,356 83	$55,930 07	$207,426 76	
13	-$119,686.55	$265,531.78	$127,809 18	$393,340.96	$273,654 41	$55,930.07	$217,724 34	
14	-$122,080.28	$278,808 37	$127,809 18	$406,617.55	$284,537.27	$55,930.07	$228,607.20	
15	-$124,521.89	$292,748.79	$127,809.18	$420,557.97	$296,036 08	$55,930 07	$240,106 01	
16	-$127,012.33	$307,386 23	$127,809.18	$435,195 41	$308,183 08	$55,930 07	$252,253 01	
17	-$129,552.57	$322,755.54	$127,809 18	$450,564.72	$321,012.14	$55,930 07	$265,082.07	
18	-$132,143.62	$338,893.31	$127,809 18	$466,702 49	$334,558 87	$55,930 07	$278,628 80	
19	-$134,786 50	$355,837.98	$127,809.18	$483,647.16	$348,860 66	$55,930 07	$292,930 59	
20	-$137,482.23	$373,629.88	$111,138 41	$484,768.29	$347,286 06	$55,930 07	$291,355 99	
						Total	$4,016,986.19	
	AAR	0.3591						

6.3 Results of financial analysis

Therefore, following results of financial indicators are found

NPV15% = $ 252227.56

IRR = 19%

PI or BCR= 1.15

Normal pay back period = 5.72 years

Discounted pay back period = 11.95 years

AAR= .36 (36%)

The results show that the project is financially feasible.

6.4 Sensitivity Analysis

During investigating a new project, naturally, the first thing is to estimate NPV based on projected cash flows. This initial set of projections is the base case. Now, however, the possibility of error in these cash flow projections is recognized. After completing the base case, it is wished to investigate the impact of different assumptions about the future on the estimates.

One way of recognizing this investigation is to put an upper and lower bound on the various components of the project. Picking these upper and lower bounds do not necessarily rule out the possibility that the actual values could be outside this range. What is said, again loosely speaking, is that it is unlikely that the true average of the possible values is outside this range.

6.4.1 Scenario Analysis

The basic form of "what – if" analysis is called scenario analysis. Scenario analysis is the determination of what happens to NPV estimates when we ask what- if questions. What we do is investigate the changes in our NPV estimates that result from asking questions.

Once starting to look at alternative scenarios, it might be found that some of the plausible ones result in positive NPVs. In this case, there has some confidence in proceeding with the project. If a substantial percentage of the scenarios look bad, then the degree of forecasting risk is high and further investigation is in order.

There are a number of possible scenarios that can be considered. A good place to start is with the worst-Case scenario. This will give minimum NPV of the project. If this turns out to be positive, the project will be in a good shape. At this position, it is necessary to go ahead and determine the other extreme, the best case. This puts an upper bound on NPV.
To get the worst case, the least favorable value is assigned to each item. This means low values for items like gas consumption through the proposed meters and low gas price and high investment cost. The reverse is done for the best case. It is to mention that in assessing the reasonableness of an NPV estimate, it is needed to stick to cases that are reasonably likely to occur.

In broad terms, thinking about a reasonable range, then what can be called that the best case would correspond to something near the upper end of that range. The worst case would simply correspond to the lower end. There are an unlimited number of different scenarios that could be examined. At a minimum, it might be wanted to investigate two intermediate cases be going halfway between the base amounts and the extreme amounts. This would give five scenarios in all, including the base case. Beyond this point, it is hard to know when to stop. As more and more possibilities are generated, it is runthe risk of experiencing "paralysis of analysis." The difficulty is that no matter how many scenarios are run, all that can be learned are possibilities, some good and some bad. Beyond that, no guidance is found as to what to do. Scenario analysis is thus useful in telling what can happen and in helping gauge the potential for disaster.

Sensitivity analysis is a variation on scenario analysis that is useful in pinpointing the areas where forecasting risk is especially severe. It is the process of investigation of what happens to NPV when only one variable is changed. The basic idea with a sensitivity analysis is to freeze all of the variables except one and then see how sensitive our estimate of NPV is to changes in that one variable. If NPV estimate turns out to be very sensitive to relatively small changes in the projected value of some component of project cash flow, then the forecasting risk associated with that variable is high.

In this project, three main variables for sensitivity analysis are- Investment cost, Gas price and Gas consumption. Sensitivity analysis has been made at the base condition, best condition, worst condition and intermediate condition for each of these parameters.

6.4.2 Sensitivity analysis for change of gas price

Present distribution margin for $1m^3$ domestic use of natural gas is \$ .0101571. Projected increase of gas price is 5%, which is the base condition. 2% increase of gas price is the worst condition. 10% increase of gas price is the best condition. Table 6.5 shows the results of NPV and IRR for various gas price changes.

Table-6.5: Sensitivity of NPV and IRR at different gas price change

Percentage increase of gas price	NPV(at 15% dr)	IRR
2% (worst condition)	$5,456.24	15.6%
5%(base condition)	$2,59,227.56	18.9%
10% (best condition)	$7,61,964.06	23%

6.4.3 Sensitivity analysis for change of Investment cost

With an initial investment estimate of $11,18,601.43 the present project is viable with BCR of 1.15 and NPV of $2,59,227.56, IRR of 18.9%. Sensitivity analysis is done at 25% increase (worst condition), 25% decrease of investment cost (best condition).

Table 6.6 shows the results of NPV and IRR for change of estimated investment cost.

Table-6.6: Sensitivity of NPV and IRR at changes of estimated investment cost

Change of investment cost	NPV ($)	IRR (%)
25% increase of investment cost (worst condition)	- 20,423.00	14.4
10% increase of investment cost	14,7367	16.5
Base condition	2,59,227.56	18.9
25% decrease of investment cost (best condition)	5,38,878	24.0

6.4.4 Sensitivity analysis for change of Gas consumption

The estimated gas consumption has also uncertainty. The amount of projected gas consumption through the proposed meters may vary. Beyond the base condition (projected condition), the analysis is done for upper bound, lower bound and an intermediate condition. Table 6.7 shows the results of NPV and IRR for change of estimated gas consumption.

Table-6.7: Sensitivity of NPV and IRR at changes of estimated gas consumption

Status of gas consumption	NPV	IRR
25% decrease of estimated gas consumption (worst condition)	- $ 50,492.00	14.3%
Estimated gas consumption (base condition)	$2,59,228.00	18.9%
25% increase of estimated gas consumption. (Best condition)	$5,68,947.00	22%
10% decrease of estimated gas consumption. (Intermediate condition)	$1,35,340.00	17%

Comment: The results of the sensitivity analysis show that due to different assumed changes in gas price, NPVs remain positive and IRRs are above the required rate of return. Even at the worst condition (2% increase of gas price), NPV is positive ($5,456.24) and IRR is acceptable(15.6%) making the project financially viable .So the project is not sensitive to assumed gas price changes. The results from change of investment cost, it is seen that the project is financially feasible in all other changes of investment cost except 25% decrease of investment cost (worst condition). At 25% decrease of investment cost NPV is negative (- $ 20,423.00) and IRR is less (14.4%), making the project a losing concern. The results from change of gas consumption, it is seen that the project is financially feasible in all other changes of gas consumption except 25% decrease of gas consumption (worst condition). At 25% decrease of gas consumption, NPV is negative (- $ 50,492.00) and IRR is less (14.3%), making the project financially unviable.

6.5 Estimation of waste gas

Total no of domestic customers in Titas Gas Franchise area is 10,97,478 (up to June, 2006). Actually 6 to 8 hours a day are required to use the burners to satisfy the cooking needs of this type of customers on an average which is revealed by the survey conducted by TGTDCL. Therefore, an operational pattern of 8 hours/ day is included in Gas Sales Contract for domestic customers. But many customers keep their burners on more than 10 hours. They keep their burners on for hours unnecessarily just to save a match- stick, which results in huge loss of natural gas. The customers do not bother to waste huge amount of gas because gas is not metered and the customers have not to pay for the waste gas. This waste gas could earn revenue and could be used for more productive other uses such as industrial use

On the basis that the burners are kept full open for 6 hours and partial open for 4hours, the following calculation is made in regard to waste gas.

Experiments made by the gas load calculation committee revealed that gas load for a domestic double burner was 21 cft / hr

Practical tests were also conducted by the author to estimate gas consumption of a domestic double burner at a very low opening and full opening. The result showed that for a very low opening 3.5 cft / hr gas is consumed. (Below which burning does not occur). Based on the above experiment, following calculations are made.

If a domestic double burner is kept full open for 6 hrs/day on an average, then, monthly load = 21x6x30/35.3147 m^3/ burner

= 107.04 m^3/ burner

If a domestic double burner is kept at a very low opening for 4 hrs/day on an average, then, monthly load = 3.5x4x30/35.3147 m^3/ burner

= 11.89 m^3/ burner.

Therefore, the total amount of gas consumed per burner per month = 107.04 m^3+11.89 m^3

= 118.93 m^3

Domestic burners are charged on the flat rate basis of Tk. 400/month. On the other hand, domestic metered customers are billed at the rate of Tk. 4.59 / m3

Tk. 400 is accounted for the amount of $\frac{400}{4.59}$ m^3 gas or, 87.146 m^3

The monthly amount of waste (not considered) gas

= (118.93-87.146) m3 =31.78 m3

The total amount of predicted waste gas for 10,000 burners = 31.78x10000 m3

= 317840 m3

= 0.31784MMCM

The monthly loss of revenue in this regard

= Tk. 317840x 4.59

= Tk. 1458885.6

= Tk.14.59 lac

Annual projected Waste of NG through 10,000 burners=0 .31784x12 MMCM

= 3.81MMCM

Annual loss of revenue = Tk. 14.59x 12 lac

= Tk. 175.08 lac

= Tk.1.75crore

Loss of distribution margin = $\frac{0.74}{4.59}$ x 1.75 crore / year

= Tk 0.28crore / year.

If we consider all the domestic customers (1097478), the total amount of waste gas in volume and TK for all the domestic burners are calculated and shown below.

Annual loss of revenue = TK0.28x1097478/ 10000crore

= Tk30.73crore

Annual projected Waste of NG through 10,000 burners= 3.81MMCM

Annual projected Wastage of NG for all the customers = 418.14 MMCM

This huge amount of gas would be sold to other type of customers (Industry, Commercial etc) at a higher rate.

6.6 Benefits of Gas Pre-paid Meters

a) The pre-paid metering system will reduce the wastage of scarce and costly natural resource.

b) Customers are billed on the basis of actual consumption

c) Eradicating fear of arrear billing and bad debt

d) Eliminating manual billing, billing book, ledger maintenance etc

e) Eradicating extra revenue staff requirement for billing and bill collection purpose.

l) Modernized and smart system.

6.7 Drawbacks of existing Gas Pre-paid Metering System.

1 LCD (Liquid Crystal Disc) display damage due to generation of excessive temperature.

2 Prolonged use of one time battery is not available.

3. Microprocessor program is not adequate.

4. IC card charging problem.

5. Meter calibration is faulty

6 Data acquisition system has not been developed.

7. IC card supply through Banks is not an efficient way for pre-paid metering system monitoring.

8. Pilot Project has not been designed properly to calculate the savings of waste gas. It was possible to estimate the wastage gas if a master meter was set to measure the consumption of the customers before introducing pre paid meters. Then it was possible to estimate the waste gas comparing the consumption of the customers before and after the implementation of the pilot project.

9 Another loophole of the pilot project is that the proper sampling method has not been applied. The customers of different consumption patters have not been included in this project. Without choosing the different consumption patterns, the customers of a similar consumption pattern in a particular area (Banani) have been chosen. Stratified sampling of the different consumption patterns could reveal more reliable result.

CHAPTER 7: SCALABILITY OF THE PILOT PROJECT

There are more than 10 lac domestic customers in Titas Gas Franchise area. The analysis is made for a lot of 10,000 pre-paid meters for 10,000 domestic customers. The analysis will be done in a larger scale for all the domestic customers (10,97,478 Domestic burners, up to June 2006) in Titas Gas Franchise area.

7.1 Cash Flow Analysis

The following sequential analysis is done.

A. Initial investment analysis

1.Meter price @ $80/meter, CIF Value	$8,77,98,240.00
2. Pipe line and accessories	$1,31,69,736.00
3 Installation	$1,31,69,736.00
4 Server and POS terminal equipment with sgms	$14,84,887.73
5 POS Office set up	$4,28,571.50
6. IC card cost	$4,38,991.20
7 Training of Titas personnel	$1,25,000.00
8. Vehicle	$12,50,000.00
Total	**$11,78,65,162.43**

B. Operational cost:

	Per year
1. Services and maintenance	$23,57,303.25
2.Utility expenses	$1,00,000.00
3. Rent	$10,00,000.00
4. Salaries and wages	$20,00,000.00
5. Administrative overhead	$5,00,000.00
Total	**$59,57,303.25**

C. Cash inflow

Estimated gas sale through each meter 1,455.71 CM Per year

Estimated gas sale through 1097478 meter	1,59,76,10,882.27 CM Per year
Revenue margin for the distribution @ 0.0101571/CM	$1,62,27,093.49
Meter rent collected annually from 10,97,478Nos	$1,40,26,775.92
Total Cash in flow for the first year	**$3,02,53,869.41**

7.1.1 Break –up of the expenses for items described in A & B are given below.

Utility expenses is assumed to be Tk.$ 1,00,000.00 annually. Rent for office is $10,00,000.00; administrative overhead is $ 5,00,000 annually. Salary of people for running all the domestic customers is assumed to be 50 times the projected cost considered for 10000 meters. Therefore, the total cost rises to in this regard

= $ 40000x 50

= $2000000

Pipe line and accessories cost:

Pipe= 20' per customer.

So. cost= Tk. 20x 36 = Tk.720

Fitting (Elbow + Socket)= Tk.30

Valve= Tk. 100

So. Total= Tk. 850=$ 12

Therefore. total cost for 1097478 meters=TK. 12x 10,97,478

= TK. 13,169,736

Cost of server and POS terminal equipment with SGMS

5 Nos. of Vending machine (VM) @ $ 296	$	1,480 00
1 No of server	$	4,700 00
5 Nos. of workstations @ $ 1050	$	5,250.00
1 No. Server UPS	$	250.00
5 Nos. workstations UPS @ 2000	$	1,000.00
Printer 2 No (with software)	$	850.00
Total	$	13,530.00

The total Cost of server and POS terminal equipment with SGMS for 1097478 no meters in this regard rises to = $13530x1097478/10000 = $ 1484887.73

Training cost of Titas personnel (for projected 10000 meters)

(a) Installation / Operation/ Maintenance and Trouble shooting	(6 persons x 10 wks)	Lump Sump $ 2500
(b) Data entry operator	(8 persons x 5 weeks)	
(c) Data Base Administrator	(2 persons x 6 wks)	
(d) Gas selling management system	(2 persons x 5 wks)	

The total Cost of Training of Titas personnel for 1097478 no meters is 50 times the projected cost considered for 10000 meters rises to =$ 2,500x 50

= $12,5000

Vehicle Cost:

4 Pick up @ $ 12,500 = $ 50,000

The total Cost of vehicles for 1097478 no meters is 50 times the projected cost considered for 10000 meters rises to =$ 50000x 25

= $1250000

7.2 Cash inflow Analysis (Calculation Details)

Estimated gas sale through each meter = 21 cft / hr

$$= \frac{21 \times 8 \times 30 \times .85}{35.3147} \ m^3 / month$$

$$= 121.309 \ m^3 / month$$

Operational/ utilization pattern :

8 hrs / day, 30 days / month, diversity factor = 0.85

Annual gas sale through each meter = 121.309 x 12

= 1,455.711078 m^3

Annual gas sales through 10,97,478 no. meters = 1,59,76,10,882 m^3

Revenue margin for the distributor @ $ 0.0101571/ m^3

Revenue earned from gas sales through 10,97,478 meters= $ 0.0101571 x 1,59,76,10,882

= 1,62,27,093.49

Meter cost $ 8,77,98,240 (for 10,97,478 meters) is amortized in 20 years. Considering the interest rate of 15% amortization table (attached in the annexure of this report) shows that Meter rent collected annually is $ 1,40,26,775.92 (except the last (20th) years

So the total revenue collected for the first year

= $ (1,62,27,093.49+1,40,26,775.92)

= $3,02,53,869.41

Table- 7.1: Calculating net cash flows and NPV at various discount rates

Year	Total cash out flow	Cash in flow from gas sales	Cash inflow from meter rent	Net cash flow (B+C+D)	Present value at various discount rate					
					15%		20%		25%	
					Present worth factor	Present value	Present worth factor	Present value	Present worth factor	Present value
0	-$117,865,162.43	$0.00		-$117,865,162.43	1	-$117,865,162.43	1	-$117,865,162.43	1	-$117,865,162.43
1	-$5,957,303.25	$16,227,093.49	$14,026,775.92	$24,296,566.16	0.86957	$21,127,448.54	0.83333	$20,247,138.47	0.8	$19,437,252.93
2	-$6,076,449.31	$17,038,448.16	$14,026,775.92	$24,988,774.77	0.75614	$18,895,103.30	0.69444	$17,353,315.81	0.64	$15,992,815.85
3	-$6,197,928.30	$17,890,370.57	$14,026,775.92	$25,719,168.19	0.65752	$16,910,770.57	0.5787	$14,883,777.89	0.512	$13,168,214.11
4	-$6,321,937.87	$18,784,889.10	$14,026,775.92	$26,489,727.16	0.57175	$15,145,587.45	0.48225	$12,774,752.68	0.4096	$10,850,192.24
5	-$6,448,376.62	$19,724,133.56	$14,026,775.92	$27,302,532.85	0.49718	$13,574,184.15	0.40188	$10,972,275.61	0.32768	$8,946,493.97
6	-$6,577,344.16	$20,710,340.25	$14,026,775.92	$28,159,772.00	0.43233	$12,174,246.53	0.3349	$9,430,650.63	0.26214	$7,381,915.27
7	-$6,708,891.04	$21,745,857.25	$14,026,775.92	$29,063,742.15	0.37594	$10,926,137.18	0.27908	$8,111,157.03	0.20972	$6,095,103.49
8	-$6,843,068.86	$22,833,150.11	$14,026,775.92	$30,016,857.17	0.3269	$9,812,563.85	0.23257	$6,980,961.62	0.16777	$5,035,992.96
9	-$6,979,930.24	$23,974,807.61	$14,026,775.92	$31,021,653.30	0.28426	$8,818,299.99	0.19381	$6,012,204.24	0.13422	$4,163,655.82
10	-$7,119,528.84	$25,173,547.99	$14,026,775.92	$32,080,795.07	0.24718	$7,929,881.90	0.16151	$5,181,227.51	0.10737	$3,444,649.14
11	-$7,261,919.42	$26,432,223.39	$14,026,775.92	$33,197,081.90	0.21494	$7,135,487.77	0.13459	$4,467,928.38	0.0859	$2,851,607.62
12	-$7,407,157.81	$27,753,836.66	$14,026,775.92	$34,373,454.78	0.18691	$6,424,644.47	0.11216	$3,855,211.70	0.06872	$2,362,125.83
13	-$7,555,300.96	$29,141,528.50	$14,026,775.92	$35,613,003.45	0.16253	$5,788,105.68	0.09346	$3,328,529.45	0.05498	$1,957,845.57
14	-$7,706,406.98	$30,598,604.92	$14,026,775.92	$36,918,973.86	0.14133	$5,217,709.03	0.07789	$2,875,492.09	0.04398	$1,623,713.64
15	-$7,860,535.12	$32,128,535.17	$14,026,775.92	$38,294,775.97	0.12289	$4,706,216.78	0.06491	$2,485,540.49	0.03518	$1,347,377.65
16	-$8,017,745.82	$33,734,961.93	$14,026,775.92	$39,743,992.02	0.10686	$4,247,232.56	0.05409	$2,149,668.79	0.02815	$1,118,693.92
17	-$8,178,100.74	$35,421,710.02	$14,026,775.92	$41,270,385.20	0.09293	$3,835,087.14	0.04507	$1,860,190.13	0.02252	$929,326.46
18	-$8,341,662.76	$37,192,795.52	$14,026,775.92	$42,877,908.69	0.08081	$3,464,754.51	0.03756	$1,610,535.70	0.01801	$772,419.73
19	-$8,508,496.01	$39,052,435.30	$14,026,775.92	$44,570,715.21	0.07027	$3,131,775.60	0.0313	$1,395,101.39	0.01441	$642,331.70
20	-$8,678,665.93	$41,005,057.06	$12,197,196.45	$44,523,587.58	0.0611	$2,720,403.62	0.02608	$1,161,355.63	0.01153	$513,322.02
		NPV				$64,120,472.02		$19,271,856.36		-$9,230,107.50

7.3: Calculating IRR

IRR is calculated as follows.

$$\frac{r_b - r^*}{r_b - r_a} = \frac{NPV_b}{NPV_b - NPV_a}$$

NPV_a = positive NPV at the lower discount rate of 20% (r_a)

= $ 19271856.36

NPV_b = Negative NPV at the higher discount rate of 25% (r_b)

= $ -9230107.499

$$r^* = IRR = r_a + (r_b - r_a) \times \frac{NPV_a}{NPVa - NPV_b}$$

= 0.20+ (0.25-0.20) x 1,92,71,856.36/ 2,85,01,963.86

= .234 = 23.4

IRR = 23.4 %

7.4: Calculating profitability index (PI) or Benefit –cost ratio (BCR)

The benefit-cost ratio (BCR) or profitability index (PI) is defined as the ratio of the present value of an investment's future cash inflows and the present value of its cost. BCR or PI of this project is calculated in the table- 7.2

Table- 7.2: Calculating BCR/ PI

Year (A)	Total cash out flow (B)	Cash in flow from gas sales (C)	Cash inflow from meter rent (D)	Total cash inflow (C+D) (E)	present value of cash out flows and inflows at 15% discount rate		
					Present worth factor	Present value of cash outflows	Present value of cash inflows
0	-$117 865,162 43	$0 00		$0 00	1	-$117,865 162 43	$0 00
1	-$5,957,303 25	$16 227 093 49	$14,026,775 92	$30,253,869 41	0 86957	-$5 180 263,69	$26,307,712 53
2	-$6 070,449 31	$17,038,448 16	$14,026,775 92	$31 065,224,08	0 75614	-$4 594 668 67	$23,489,772 46
3	-$6,197 978 30	$17,890 370 57	$14 026,775 92	$31,917,146 49	0 65752	-$4 075 271 34	$20,986 041 91
4	-$6,321,937.87	$18,784 889 10	$14 026,775 92	$32 811,065 02	0,57175	-$3,614 588 49	$18 760,175 97
5	-$6,418,376 62	$19,724 133 56	$14,026 775 92	$33 750 909 48	0 49718	-$3,205,982 84	$16 780 160 99
6	-$6,577,344.16	$20,710,340 23	$14,026 775 92	$34,737,116 15	0 43233	-$2,843 567 39	$15,017,813 92
7	-$6 708 891 04	$21 745,857 25	$14,026 775 92	$35,772,633,17	0 37591	-$2,522,120 64	$13,448,257 82
8	-$6 843 068 86	$22 833,150 11	$14,026 775 92	$36,859 926 03	0 3269	-$2,237 011 35	$12 049,575 20
9	-$6,979,930 24	$23,974,807 61	$14 026,775 92	$38,101,583 53	0 28426	-$1,984,341 80	$10,802,421 80
10	-$7 119 528 84	$25,173,547 99	$14 026,775 92	$39,200,323 91	0 24718	-$1,759 838 64	$9 689,720 55
11	-$7 261 919 42	$26 432,225 39	$14 026,775 92	$40,459,001 31	0 21494	-$1,560,900 36	$8 696 388 13
12	-$7,407 157 81	$27,753,836 66	$14 026,775,92	$41,780,612 58	0 18691	-$1,384,450 76	$7 809 095 23
13	-$7,555,300 96	$29,141,528 50	$14 026,775 92	$43,168,304 42	0 16253	-$1,227,947 63	$7,016,056 31
14	-$7,706,406 98	$30,598,604 92	$14 026,775 92	$44 625,480 84	0 14133	-$1,089,136 16	$6,306 845 19
15	-$7,860 535 12	$32 128 535 17	$14,026,775 92	$46,155,311 09	0 12289	-$966,016 42	$5,672,233 20
16	-$8,017 745 82	$33 734,961 93	$14,026,775,92	$47,761,737 85	0 10686	-$856,814 56	$5,104 047 12
17	-$8,178,300 74	$35,421,710 02	$14,026,775 92	$49,448,485 94	0 09293	-$759,957 26	$4,595,034 40
18	-$8 341,662 76	$37,192 795 52	$14,026,775 92	$51 219,571 44	0 08081	-$674 049 05	$4 138,803 56
19	-$8,508,496 01	$39,052,435 30	$14,026 775 92	$53,079,211 22	0 07027	-$597,852 20	$3 729 627 80
20	-$8,678,665 93	$41,005,057.06	$12,197 196 45	$53,202,253 51	0 0611	-$530,268 91	$3 250 672 53
					Total	-$159,530,080,60	$223,650,472.62
	BCR	1.401934					

7.5 Calculating pay back period.

The amount of time required to recover the initial investment is the pay back period. If the future cash flows are not discounted to calculate pay back period then it is called normal pay back period. But when future cash flows are discounted at an appropriate discount rate, then the required time to recover the initial investment is called discounted pay back period. Discounted and undiscounted cash flows for pay back period calculation are shown in the table- 7.3.

Table- 7.3: Undiscounted and discounted cash flows for pay back period

Initial Investment = $ 11,78,65, 162.43

Year	Cash Flow		Accumulated cash flow	
	Undiscounted ($)	Discounted (At required rate of 15%) ($)	Undiscounted ($)	Discounted (At required rate of 15%) ($)
1	2,42,96,566.16	2,11,27,448 84	2,42,96,566.16	2,11,27,448 84
2	2,49,88,774.77	1,88,95,103.80	4,92,85,340.33	4,00,22,552.64
3	2,57,19,168 19	1,69,10,770.57	7,50,04,508.52	5,69,33,323 21
4	2,64,89,727.16	1,51,45,587 48	10,14,94,235.70	7,20,78,910.69
5	2,73,02,532.85	1,35,74,184.15	12,87,96,768.50	85,65,094 84
6	2,81,59,772.00	1,21,74,246.53	15,69,56,540.5	9,78,27,341.37
7	2,90,63,742.13	1,09,26,137.18	18,60,20,282.7	10,87,53,478.60
8	3,00,16,857 17	98,12,563.85	21,60,37,139.8	11,85,66,042 40
9	3,10,21,653.30	88,18,289.99	24,70,58,793.1	12,73,84,332.40
10	3,20,80,795 07	79,29,881.90	2,791,39,588.2	13,53,14,214.30

From the table it is clear normal pay back period is greater than 4 years but less than 5 years

Pay back period = 4 +(11,78,65,162.43- 10,14,94,235.70) /(12,87,96,768.50- 10,14,94,235.70) years = 4+ 1,63,70,926.7/2,73,02,532 8

= 4.60 years

From discounted accumulated cash flow column it is seen that the initial investment is recovered or get our bait back between 7 and 8 years.

Discounted pay back period = 7 + (11,78,65,162.43- 10,87,53,478.6) /(118566042.40- 108753478.6) years= 7+ 91,11,683 8/ 98,12,563.8

= 7.93 years

7.6 Calculating Average Accounting Return (AAR)

AAR is a financial indicator, which is defined as the ratio of average net income and average book value AAR is calculated in the table- 7.4.

Table- 7.4: Calculating AAR

Year (A)	Expenses (B)	Cash in flow gas sales (C)	Cash inflow from meter rent (D)	Total Revenue(C+D) (E)	FBD(E−B) (F)	Depreciation (G)	NPNI (F-G) (H)	Avg Net Income (I)
1	-$5,957,303.25	$16,227,093.49	$14,026,775.92	$30,253,869.41	$24,296,566.16	$5,893,258.12	$18,403,308.04	
2	-$6,076,449.31	$17,038,448.16	$14,026,775.92	$31,065,224.08	$24,988,774.77	$5,893,258.12	$19,095,516.65	
3	-$6,197,978.30	$17,890,370.57	$14,026,775.92	$31,917,146.49	$25,719,168.19	$5,893,258.12	$19,825,910.07	
4	-$6,321,937.87	$18,784,889.10	$14,026,775.92	$32,811,665.02	$26,489,727.16	$5,893,258.12	$20,596,469.04	
5	-$6,448,376.62	$19,724,133.56	$14,026,775.92	$33,750,909.48	$27,302,532.85	$5,893,258.12	$21,409,274.73	
6	-$6,577,344.16	$20,710,340.23	$14,026,775.92	$34,737,116.15	$28,159,772.00	$5,893,258.12	$22,266,513.88	
7	-$6,708,891.04	$21,745,857.25	$14,026,775.92	$35,772,633.17	$29,063,742.13	$5,893,258.12	$23,170,484.01	
8	-$6,843,068.86	$22,833,150.11	$14,026,775.92	$36,859,926.03	$30,016,857.17	$5,893,258.12	$24,123,599.05	
9	-$6,979,930.24	$23,974,807.61	$14,026,775.92	$38,001,583.53	$31,021,653.30	$5,893,258.12	$25,128,395.18	
10	-$7,119,528.84	$25,173,547.99	$14,026,775.92	$39,200,323.91	$32,080,795.07	$5,893,258.12	$26,187,536.95	
11	-$7,261,919.42	$26,432,225.39	$14,026,775.92	$40,459,001.31	$33,197,081.90	$5,893,258.12	$27,303,823.78	
12	-$7,407,157.81	$27,753,836.66	$14,026,775.92	$41,780,612.58	$34,373,454.78	$5,893,258.12	$28,480,196.66	
13	-$7,555,300.96	$29,141,528.50	$14,026,775.92	$43,168,304.42	$35,613,003.45	$5,893,258.12	$29,719,745.33	$27,632,915.25
14	-$7,706,406.98	$30,598,604.92	$14,026,775.92	$44,625,380.81	$36,918,973.86	$5,893,258.12	$31,025,715.74	
15	-$7,860,535.12	$32,128,535.17	$14,026,775.92	$46,155,311.09	$38,294,775.97	$5,893,258.12	$32,401,517.85	
16	-$8,017,715.82	$33,734,961.93	$14,026,775.92	$47,761,737.85	$39,743,992.02	$5,893,258.12	$33,850,733.90	
17	-$8,178,100.74	$35,421,710.02	$14,026,775.92	$49,448,485.94	$41,270,385.20	$5,893,258.12	$35,377,127.08	
18	-$8,341,662.76	$37,192,795.52	$14,026,775.92	$51,219,571.41	$42,877,908.69	$5,893,258.12	$36,984,650.57	
19	-$8,508,496.01	$39,052,435.30	$14,026,775.92	$53,079,211.22	$44,570,715.21	$5,893,258.12	$38,677,457.09	
20	-$8,678,665.93	$41,005,057.06	$12,197,196.45	$53,202,253.51	$44,523,587.58	$5,893,258.12	$38,630,329.46	
						Total	$552,658,305.06	
	AAR	0.4688903						

7.7 Results:

The following results of financial indicators are found

NPV15% = $ 6,41,20,472.02

IRR = 23.4%

PI or BCR= 1.40

Normal pay back period = 4.60 years

Discounted pay back period = 7.93 years

AAR= .4689 (46.89%)

The results show that the project is financially better feasible if it is implemented for all domestic customers.

CHAPTER 8: CONCLUSIONS AND RECOMMENDATIONS

8.1. Conclusions

The objectives of this project are to analyze the existing gas pre-paid metering of the 1000 domestic customers brought under the pilot project, to evaluate the outcomes, benefits and difficulties experienced in this project.

The following conclusions are made from this study

i) Pilot Project has not been designed properly to calculate the savings of waste gas. It would have been possible to estimate the wastage gas if a master meter was set to measure the consumption of the customers before introducing pre paid meters. Then it was possible to estimate the waste gas comparing the consumption of the customers before and after the implementation of the pilot project

ii) Another loophole of the pilot project is that the proper sampling method has not been applied. The customers of different consumption patters have not been included in this project. Without choosing the different consumption patterns, the customers of a similar consumption pattern in a particular area (Banani) have been chosen. Stratified sampling of the different consumption patterns could reveal more reliable result.

iii) Some technical problems found in the meters negatively affected the project outcome. Most frequently occurring problems are:

- Calibration Problem
- Lower quality of battery, Local Crystal Display (LCD)
- Poor quality of IC cards etc

iv) Project is financially feasible as NPV, Discounted Pay Back Period, Pay Back Period, IRR, BCR or PI and AAR are $ 252227.56, 11.95 years, 5.72 years, 19%, 1.15,0.36 or 36% respectively.

v) It is found in this study that for assumed consumption pattern The pre-paid metering system will eliminate the wastage of scarce and costly natural resource.

vi) Customer survey of the test pre-paid metering of domestic customers shows that 19%are satisfied, 14% are dissatisfied and 67 % are inert to comment.

Satisfied customers commented that their bills have been reduced in regard to flat rate billing. They also advocated the billing system on actual consumption. The customers who were dissatisfied about the pre paid metering said that meters have some problems such as locking, battery damage etc.

vii) The scalability analysis shows that the project is also viable if it is applied to all the domestic customers in Titas franchise area providing NPV, Discounted Pay Back Period, Pay Back Period IRR, BCR or PI and AAR are $ 64120472.02, 7.93 years, 4.60 years, 23.4%, 1.40, 46.89% respectively.

8.2. Recommendations

In view of the findings of this study, following recommendations are made:

i) Customers should have a unique smart card for monitoring and data acquisition of the customers' gas consumption.

ii) Point of Sales (POS) terminal should be opened for 12 hrs and everyday in a week. The entire terminals should be brought under a unique database so that the data can be automatically stored in a single database.

iii) The consumed gas amount, the balanced amount. battery status installed inside the meter. meter number and customer ID number should be introduced in the smart card to avoid illegal use of smart card and meter. The meter should be unique for a single smart card.

iv) A strong backup data base system should be incorporated to avoid any unexpected failure of the server as well as a hard database should be established.

v) The battery of the meters should be rechargeable instead of one time use. There should be a charging facility inside the meter as well as in customers' premises to recharge the battery. At least 5% excess amount of meter, battery, smart card and other spare parts should be at hand. At least one emergency team has to be engaged for two or three Zonal area to provide an uninterrupted service to the customers.

vi) Though the mechanical portion of the existing gas pre-paid meters have no problem in accuracy and calibration, electrical module is not calibrated accurately with respect to mechanical counter. There fore, electrical module is necessary to be calibrated properly.

vii) Liquid crystal disk (LCD) display is of lower quality. It can't withstand high temperature (above 60^0 F). Better quality of LCD is required. The battery and the IC cards should be of higher quality. The existing battery and the IC cards are of lower quality.

viii) Meters should be installed at least 5' away from the burners and at the same level or lower level of the burners. As a result, the effect of heat will be diminished.

ix) Before any large scale implementation of pre paid metering, another project may be undertaken with the findings of this study taken into consideration that stratified random sample of customers of different consumption patterns and master metering for providing base line data.

REFERENCES

Cooper, D. R and Schindler, P.S (2006): *Business Research Methods*, Mcgraw-Hill International Edition, Newyork.

Larson, K. D. (1997): *Essentials of Financial Accounting*. Michael W.Junior, New Delhi.

Petrobangla (2005-2006): Annual Report

Petrobangla (January 2007): Monthly Report

Ross Stephen A., Westerfield Randolph W. and Jordan Bradford D. (2003): *Fundamentals of Corporate Finance*. Tata McGraw-Hill. New Delhi.

TGTDCL (2005-2006): Annual Report

TGTDCL (2004-2005): Annual Report.

TGTDCL (2003-2004): Annual Report

TGTDCL (1990): Report on the silver jubilee of Titas Gas T & D

APPENDIX

APPENDIX-A

Profitability analysis

Any one or a combination of the following commonly used tools are applied in the analysis of a project from profitability point of view:

a) Net Present Value (NPV)

b) Benefit Cost Ratio (BCR) or Profitability Index (PI)

c) Internal Rate of Return (IRR)

d) Discounted Pay-Back Period

e) Pay-Back Period (PBP)

f) Average Accounting Return (AAR)

The first four profitability tools i.e. NPV, BCR, IRR and Discounted Pay-Back Period takes into account the relative timing of cost and benefit flows through the process of discounting to consider time value of money.

Discounting

Calculating the present value of some future amount is called discounting. It is a process of translating future into their present worth by applying a set of discount factors that reflect the diminishing value of the same amount of money or resources as one moves further into the future, conversely, compounding is a process of translating present value into their future worth by applying a set of compound factors. The techniques of discounting and compounding are the two basic ways of taking the time value concept of money into consideration. Discounting recognizes that the same amount of money will be less worthwhile in the future.

Discount rate

The rate used to calculate the present value of future cash flows.

Compounding and discounting procedure:

Compounding:

The formula for compounding any amount of investment is:

$$Pn = P_o(1+r)^n \qquad (6.1)$$

Where, Pn	=	the value of Po at some future year, N
P_o	=	the value of investment at year zero
r	=	interest rate
n	=	the compounding period

Discounting:

The discounted present vale may be derived through the formula:

$$P0 = P_n / (1+r)^n \qquad (6.2)$$

Where.	P_n	=	Present value
	P_o	=	expected revenue at some future year, N
	r	=	discount rate, and
	n	=	the discounting period.

The Net Present Value (NPV)

Net present value (NPV) is the difference between an investment's market value and its cost. Net present value (NPV) of an investment project can be derived as the difference between the present value of benefits (PVB) and present value of costs (PVC) i.e. NPV= PVB. PVC. In other words, NPV is the difference between the present value of all cash inflows and present value of all cash outflows. The NPV criterion is an absolute figure to decide whether in a particular project or a number of alternative projects should be made or not. An investment is worth undertaking if it creates value for its investor. In the most general sense, we create value by identifying an investment worth more in the marketplace than it costs us to acquire.

Decision Rule:

An investment should be accepted if the net present value (NPV) is positive and rejected if it is negative. In the unlikely event that the net present value turned out to be exactly zero, we would be indifferent between taking the investment and not taking it.

$$NPV = \sum_{i=0}^{n} \frac{b_i - c_i}{(1+r)^i} \qquad (6.3)$$

Where,

$$NPV = \frac{b_0 - c_0}{(1+r)^0} + \frac{b_1 - c_1}{(1+r)^1} + \frac{b_2 - c_2}{(1+r)^2} + \dots\dots\dots + \frac{b_n - c_n}{(1+r)^n} \qquad (6.4)$$

b_i = benefits derived from the project in year i.

c_i = Cost (investment, operating and other associated expenses) Incurred by the project in year i.

r = discount rate

i = time period which runs from year zero to year n.

The Benefit-Cost Ratio (BCR) or Profitability Index (PI)

The benefit-cost ratio (BCR) or profitability index (PI) is the present value of an investment's future cash inflows divided by the present value of its cost. The Benefit-Cost

Ratio (BCR) is derived by dividing present value of benefit (PVB) by present value of cost (PVC) i.e. BCR = PVB/PVC. The benefit cost ratio indicates benefit per taka of cost.

More generally, if a project has a positive NPV, then the present value of an investment's future cash inflows must be bigger than the present value of the investment's costs. The benefit-cost ratio (BCR) or profitability index (PI) is thus bigger than 1 for a positive NPV investment and less than 1 for a negative NPV investment.

Decision Rule:

If PI or BCR is more than one, investment in the project is worthwhile.

Net Present Value and benefit cost ratio my not provide the same ranking of the projects. In an investment decision, therefore, selection of investment criteria is important. As long as we are concerned with a single project or two or more projects whose costs are the same the NPV criterion is adequate. But in a situation with differing costs, BCR provides a relative measure of worthwhile ness to the project.

Formula:

$$BCR = \frac{\sum_{i=0}^{n} \frac{b_i}{(1+r)i}}{\sum_{i=0}^{n} \frac{c_i}{(1+r)i}} = \frac{PVB}{PVC} \qquad (6.5)$$

Where,

b_i	=	benefits in derived .
c_i	=	Cost in period i.
r	=	discount rate
n	=	Discounting period.
PVB	=	Present value Benefit.
PVC	=	Present value Cost

The Internal Rate of Return (IRR)

The Internal Rate of Return (IRR) is that discount rate at which Net Present Value is zero and benefit cost ratio is one i.e. it is the discount rate that equates the present values of project's benefits and costs. IRR does not depend upon externally given social rate of discount. Conversely. what it represents is essentially the average earning power of money used in project over the project life.

Decision Rule:

Investment decision is taken by comparing the internal rate of return of a specific project, with a cut-off rate, which gives the minimum acceptable rate at which the capital invested should be compounded.

The cut-off rate is equal to the actual rate of interest on loon-term loans in the capital market or to the interest rate paid by the borrower. If one has to choose among alternative projects, the one with the highest internal rate of return will be selected, provided this internal rate of return is higher than the cut-off rate.

Internal rate of return i.e. IRR should be greater than or equal to the relevant discount rate. The relevant discount rate for a private investor would be the weighted average of the market rate of interest and the yield of alternative investment opportunities. For government it would be social discount rate.

Procedure for estimating IRR:

The steps involved in the calculation of IRR are:

a) Discount the stream of annual net benefits (b_i-c_i) using different Values for the discount rate 'r' and calculate for a positive NPV and a negative NPV.

b) Interpolate using the positive NPV and negative NPV as upper and lower limits and solve for discount rate 'r' at which NPV = O.

Formula:

The equation for interpolation is:

where,

$$\frac{r_b - r^*}{r_b - r_a} = \frac{NPV_b}{NPV_b - NPV_a} \qquad (6.6)$$

r_b	=	higher discount rate.
r_a	=	lower discount rate
r^*	=	IRR to be calculated
NPV_a	=	Net present value at lower discount rate
NPV_b	=	Net present value at higher discount rate

IRR can also be calculated by using the formula:

$IRR = r_a + (r_b - r_a) x NPV_a/(NPV_a - NPV_b)$

IRR can also be found from the graph of NPV vs discount rate. The point at which the curve intersects the X-axis shows IRR. The discount rate at that point (where NPV is zero) is the IRR.

Pay Back Period

The payback period is to determine the number of years during which the cost of resources invested, can be recovered. If the time factor is an important consideration, then the project which yields income in the shortest possible time would be preferred. The project managers or investors for specific project type usually set a standard i.e. cut off payback period. The project managers or investors compare computed payback with the cut of pay back period set up. If the payback period is shorter than the cut-off pay back period then the project is acceptable. Comparison should also be made with the payback periods computed for alternative projects for ranking of purpose.

Analysis of cost-Effectiveness

Cost-effectiveness analysis is an alternative way of appraising projects. It is a method to determine whether or which program accomplishes a given objective at a minimum cost. The analysis differs from cost-benefit analysis in that input costs are calculated. The objective therefore, is determining the fulfillment of specific impacts with certain input costs.

Formula:

$$\text{Cost-Effectiveness} = \text{Efficiency} \times \text{Effectiveness}$$

$$= \frac{\text{Output}}{\text{Intput}} \times \frac{\text{Outcome}}{\text{Output}}$$

$$= \frac{\text{Outcome}}{\text{Intput}}$$

APPENDIX-B

Calculation of Net Cash Flow

For year 0

Cast outflow (investment cost) = $ (1118601.43)

Cash in flow = $ 0

Net cash flow = $ (1118601.43)

For year 1

Total cash outflow = operating cost = ($ 94372.03)

Total Cash inflow = Revenue form gas sales + Revenue form meter rent

=$147858 03 + $ 127809.18

= $ 275667.21

Net cash flow from year 1 = $ 275667.21-94372 03

= $ 181295.18

For year 2

Cash out flow = ($ 94372.03 x 1.02) (2% annual increase of the operating cost)

= ($ 96259.4706)

Cash in flow form gas sales = $ 147858.03 x 1.05 (5% annual increase of the gas price)

= $ 155250.9315

Cash inflow from meter rent = $ 127809.18

Total cash inflow = $ 155250 9315 + $ 127809.18

= $ 283060.1115

Net cash flow from year 2 = $ 283060.1115-96259 4706

= $ 186800.64

For year 3

Total cash out flow = ($ 96259.4706 x 1.02)

= ($ 98184.66001)

Total cash inflow = $ 155250.9315 x 1.05 + $ 127809.18

= 290822.6581

Net cash flow form year 3 = $ 290822.6581-98184 662007

= $ 192638.00

Calculating in this way, the net cash flows for the subsequent year are as follows which are shown in the table of this chapter

Net cash flow for year 4 = $ 198824.98

Net cash flow for year 5 = $ 205380.22

Net cash flow for year 6 = $ 212323.31

Net cash flow for year 7 = $ 219674.85

Net cash flow for year 8 = $ 227456.48

Net cash flow for year 9 = $ 235690.96

Net cash flow for year 10 = $ 244402.20

Net cash flow for year 11 = $ 253615.35

Net cash flow for year 12 = $ 263356.83

Net cash flow for year 13 = $273654.41

Net cash flow for year 14 = $284537.27

Net cash flow for year 15 = $296036.08

Net cash flow for year 16 = $308183.08

Net cash flow for year 17 = $321012.14

Net cash flow for year 18 = $334558.87

Net cash flow for year 19 = $348860.66

Net cash flow for year 20 = $347286.06

APPENDIX-C

Meter Rent Collection (Amortization of Cost of Meters)

Loan Calculator

Enter Values	
Loan Amount	$ 800,000.00
Annual Interest Rate	15.00 %
Loan Period in Years	20
Number of Payments Per Year	1
Start Date of Loan	1/1/2009
Optional Extra Payments	

Loan Summary	
Scheduled Payment	
Scheduled Number of Payments	
Actual Number of Payments	
Total Early Payments	
Total Interest	

Lender Name:

Pmt No.	Payment Date	Beginning Balance	Scheduled Payment	Extra Payment	Total Payment	Principal
1	1/1/2009	$ 800,000.00	$ 127,809.18	$ -	$ 127,809.18	$ 7,809.18
2	1/1/2010	792,190.82	127,809.18	-	127,809.18	8,980.56
3	1/1/2011	783,210.27	127,809.18	-	127,809.18	10,327.64
4	1/1/2012	772,882.64	127,809.18	-	127,809.18	11,876.78
5	1/1/2013	761,005.85	127,809.18	-	127,809.18	13,658.30
6	1/1/2014	747,347.56	127,809.18	-	127,809.18	15,707.04
7	1/1/2015	731,640.51	127,809.18	-	127,809.18	18,063.10
8	1/1/2016	713,577.41	127,809.18	-	127,809.18	20,772.56
9	1/1/2017	692,804.85	127,809.18	-	127,809.18	23,888.45
10	1/1/2018	668,916.40	127,809.18	-	127,809.18	27,471.72
11	1/1/2019	641,444.68	127,809.18	-	127,809.18	31,592.47
12	1/1/2020	609,852.21	127,809.18	-	127,809.18	36,331.34
13	1/1/2021	573,520.87	127,809.18	-	127,809.18	41,781.05
14	1/1/2022	531,739.82	127,809.18	-	127,809.18	48,048.20
15	1/1/2023	483,691.62	127,809.18	-	127,809.18	55,255.43
16	1/1/2024	428,436.19	127,809.18	-	127,809.18	63,543.75
17	1/1/2025	364,892.43	127,809.18	-	127,809.18	73,075.31
18	1/1/2026	291,817.12	127,809.18	-	127,809.18	84,036.61
19	1/1/2027	207,780.51	127,809.18	-	127,809.18	96,642.10
20	1/1/2028	111,138.41	127,809.18	-	111,138.41	94,467.85