Development of City Gas Distribution networks and Prospects of CNG & PNG in India along with its regulatory framework

Dissertation

Submitted for the partial fulfillment of the requirements for the award of the degree

Master of Business Administration

(Oil and Gas)

By

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DECLARATION

I S.Subramaniyam student of MBA (Oil & Gas management) at University of Petroleum & Energy Studies declare that work done **"Development of City Gas Distribution networks and Prospects of CNG & PNG in India along with its regulatory framework"** is original and is being submitted to University of Petroleum & Energy Studies, Dehradun in partial fulfillment for award of degree of Masters in Business Administration in oil and gas management. Any references made in this project are duly acknowledged.

To the best of my knowledge and belief the subject matter here is original and has not been submitted to any other university till date.

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BONAFIDE CERTIFICATE

This is to certify that the dissertation report on "**Development of City Gas Distribution networks and Prospects of CNG & PNG in India along with its regulatory framework**" completed and submitted to UPES, Dehradun by **S.Subramaniyam (R020206068)** for partial fulfillment of the requirement for the award of degree Master of Business Administration (Oil and Gas management), is bonafide work carried out by him under my supervision and guidance.

To the best of my knowledge and belief the work has been based on investigation made, data collected and analyzed by him and this work has not been submitted anywhere else for any other university or institution for the award of any degree or diploma.

Mr. S. Mohan
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EXECUTIVE SUMMARY:

There has been a growing concern for availability of primary commercial energy to meet the country's growth imperatives. Our economy is growing at a brisk rate of around 9% and is projected to become the 2nd largest economy of the world by 2050 as per a report by Goldman Sachs. Such growth requires a corresponding increase in the sources of energy as well as in supply infrastructure. Under these circumstances, the requirement of adequate and reliable energy supply at economic prices for optimal and inclusive growth of the country is a prime concern today.

It is in this context, that the role of natural gas as a potential source of clean and efficient energy supply becomes important. With recent promising gas discoveries made in various parts of the country and ongoing exploration activities, Natural Gas has become a vital component of India's supply of energy. It is emerging as the fuel for the future. It is more efficient in terms of output but also more as compared to the more dominant sources of energy like coal and oil. Natural gas is poised to play an important role in the development of our economy. Gas is emerging as an important policy element in achieving equitable, balanced and sustainable economic growth through widening its user base beyond industries.

Natural Gas has found its use in many areas. When natural gas use is more specified like into the cities, the natural gas is termed as city gas. All the uses of natural gas as piped natural gas to domestic households, CNG for the vehicles, commercial uses (hotels, restaurant, corporate, school, trusts, clubs, temples, burring ghats), small industries (industries with municipal limit or with the concession limit or industries consumes less than or equal to 50,000 scmd at a pressure of 19 bars) are termed as city gas. So, mainly city gas is CNG and PNG both.

Compressed Natural Gas (CNG) is a substitute for gasoline (petrol) or diesel fuel. It is considered to be an environmentally "clean" alternative to those fuels. It is made by compressing methane (CH_4) at 200 to 270 bar pressure extracted from natural gas . It is stored and distributed in hard containers, usually cylinders. CNG has grown into one of the major fuel sources used in car engines in Pakistan, Bangladesh and India. The use of CNG is mandated for the public transport system of New Delhi, India's capital city as well as mega city Ahmadabad in the state of Gujarat. The Delhi Transport Corporation operates the world's largest fleet of CNG buses. Today, many rickshaws as well as personal vehicles in India and Bangladesh are being converted to CNG powered technology

Piped Natural Gas (PNG) has several distinctions to its credit- of being a pollution-free fuel, easily accessible minus storage troubles, and being available at very competitive rates, are just a few of them. With PNG you don't need to make any choices, for its characteristics make it the best option for domestic and commercial purposes. No storage problems and stock accounting PNG does not require any storage tank or storage space since it is supplied to you through pipelines. PNG has been positioned to be cheaper than alternative fuels being used viz. domestic LPG in case of House Hold, commercial LPG in case of Small Commercial and LPG Bulk & LDO in case of Large Commercial.

Gas markets usually consist of vertically integrated monopolists in production, transmission and distribution. Gas sectors exhibit natural monopoly characteristics, including economies of scale and scope, presence of network externalities and lumpiness of investment due to technological constraints. Consequently, it is necessary to regulate energy services to prevent utilities from abusing market power. Comparison of Emerging, Developed and Mature Markets is done from which suggestions are given for designing regulatory framework of Indian Natural Gas sector with respect to transportation, transmission and distribution of gas.

CHAPTER 1: NATURAL GAS IN INDIA – AN OVERVIEW

Until the recent past, focus had been primarily on exploiting oil reserves. Immense opportunity offered by natural gas was marginalized due to:

Quest for oil

Lack of transmission and distribution infrastructure

Gas utilization was limited to few limited sectors only i.e. power/fertilizer

Rising crude prices coupled with depleting oil reserves have diverted attention towards Gas globally. Natural gas is the emerging source of energy.

With the hydrocarbons finds in India way back in 1889 in upper Assam, the journey for exploring hydrocarbons reserves continued. There had been Oil & Gas finds in various regions at various times. The major gas finds of Bombay High and South Basin change energy consumption pattern in India. Natural gas is most eco friendly fuel among the hydrocarbons group and next only to solar energy, wind energy, hydel energy and hydrogen. The Indian Energy Basket has a share of Natural gas touching 9% as against 24% of the world average.

Natural gas has come a long way from being an unwanted byproduct that must be flared and destroyed to the fastest growing primary energy source. It has the advantage of being a clean and environment friendly fuel, has better fuel efficiencies, is widely distributed geographically with much better R/P ratios, and finally, it is less prone to price fluctuations. Natural gas is becoming the second largest trading energy commodity after crude oil. It is being traded both through pipelines and in the liquefied form as LNG.

Natural gas has emerged as the most preferred fuel due to its inherent environmentally benign nature, greater efficiency and cost effectiveness. The demand of natural gas has sharply increased in the last two decades at the global level. In India too, the natural gas sector has gained importance, particularly over the last decade, and is being termed as Fuel of the 21st Century. Natural Gas is a vital component of the world's supply of energy. It is one of the cleanest, safest, and most useful of all energy sources.

1.1 WHAT IS NATURAL GAS?

Natural gas, natural mixture of gaseous hydrocarbons found issuing from the ground or obtained from specially driven wells. Some of the hydrocarbons found in gasoline also occur as vapors in natural gas; by liquefying these hydrocarbons, gasoline can be obtained. Natural gas was known to the ancients but was considered by them to be a supernatural phenomenon because, noticed only when ignited; it appeared as a mysterious fire bursting from the ground. One of the earliest attempts to harness it for economic use occurred in the early 19th cent. In Fredonia, N.Y. Toward the latter part of the 19th cent., large industrial cities began to make use of natural gas, and extensive pipeline systems have been constructed to transport gas.

Natural gas is colorless, shapeless, and odorless in its pure form and it is lighter than air. It is gaseous at any temperature over -161° C. When it is at its natural state, it is not possible to see or smell natural gas. Natural gas is neither corrosive nor toxic, its ignition temperature is high and it has a narrow flammability range making it an inherently safe fossil fuel compared to other fuel sources. In addition, because of its specific gravity of 0.60, which is lower than that of air (1.00), natural gas rises if escaping, thus dissipating from the site of any leak.

Natural gas is found throughout the world in reservoirs deep beneath the surface of the earth and floor of the oceans. It is found in oil fields, natural gas fields and in coal beds (as coal bed methane). It forms as pockets of gas over crude oil deposits or is trapped in porous rock formations. Natural gas can be found in oil deposits, as associated natural gas, although non-associated natural gas is often found without the presence of oil. Although commonly associated with petroleum deposits it also occurs separately in sand, sandstone, and limestone deposits. Because of its flammability and high calorific value, natural gas is used extensively as an illuminant and a fuel.

Natural gas is often informally referred to as simply **gas**, especially when compared to other energy sources such as electricity. Before natural gas can be used as a fuel, it must undergo extensive processing to remove almost all materials other than methane. The by-products of that processing include ethane, propane, butanes, pentanes and higher molecular weight hydrocarbons, elemental sulphur, and sometimes helium and nitrogen.

CHEMICAL COMPOSITION OF NATURAL GAS:

The composition of natural gas varies in different localities. The primary component of natural gas is methane (CH_4), the shortest and lightest hydrocarbon molecule. It also contains heavier gaseous hydrocarbons such as ethane (C_2H_6), propane (C_3H_8) and butane (C_4H_{10}), as well as other sulphur containing gases, in varying amounts, and is the primary market source of helium.

Latest Gas Composition of Natural Gas:

Methane	92.49 %
Ethane	4.9347 %
Propane	1.7085 %
N butane	0.368 %
I butane	0.2787 %
Nitrogen	0.1964 %
I pentane	0.0137 %
N pentane	0.0076 %
C6+	0.0024 %

ADVANTAGES OF NATURAL GAS

- Installation of ash precipitators and other equipment for pollution control are not required.
- Risk of breakdown in fuel supply due to order processing delays to replenish fuel inventory is eliminated.
- No storage yard required as gas is directly delivered at the end of pipe.
- Energy spent for heating up the fuel oil is saved. This saving is significant in the case of LSHS.
- Natural gas is more cleaner and environment friendly fuel than coal and petroleum products

1.2. ENERGY CONSUMPTION OVERVIEW

India is world's 5th largest energy consumer and 6th largest gas consumer but 21st largest gas producer. India is one of the fastest growing energy consumers in the world along with China. The country's energy consumption rate has grown at 4.33% over the last five years whereas world's energy consumption rate has grown at 2.85% over the last five year.

India dominantly depends on coal for its energy requirement i.e. 53% of energy requirement is met by coal, 32% by oil and 9% by natural gas. The natural gas consumption is projected to increase to 20% by 2024-25.

Yr. 2005	World	Asia Pacific	India
Energy Consumption (MTOE)	10224	3199	376
Energy Mix (%)			
Coal	27%	47%	53%
Oil	37%	34%	32%
Natural gas	24%	10%	9%
Nuclear	6%	4%	1%
Hydro	6%	5%	5%
Oil & Gas Imports (MTOE)	2467	836	98 (US$ 30 billion)
Growth in Energy (last 10 yrs)			
Total Primary Energy	2.1%	4.2%	4.8%
Natural Gas	2.6%	6.0%	6.8%

Table 1.1 Comparison of Energy mix of World, Asia Pacific and India

ENERGY DEMAND GROWTH OF 1.8%

GAS DEMAND GROWTH OF 2.3%

EMERGING ECONOMIES ENERGY DEMAND GROWS AT 3.5 TO 4%

INDIA'S ENERGY DEMAND PROJECTED TO GROW AT 5%

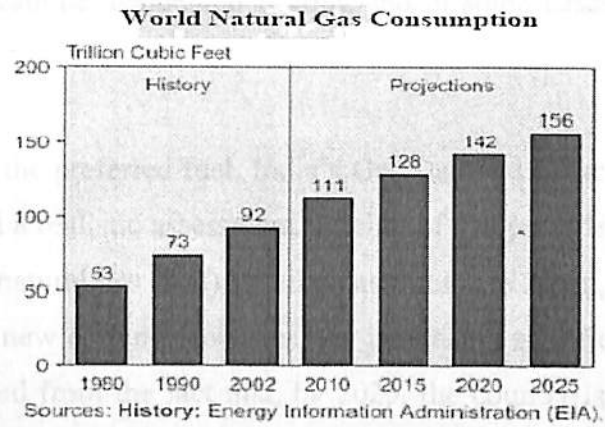


Fig 1.1 World Natural Gas Consumption

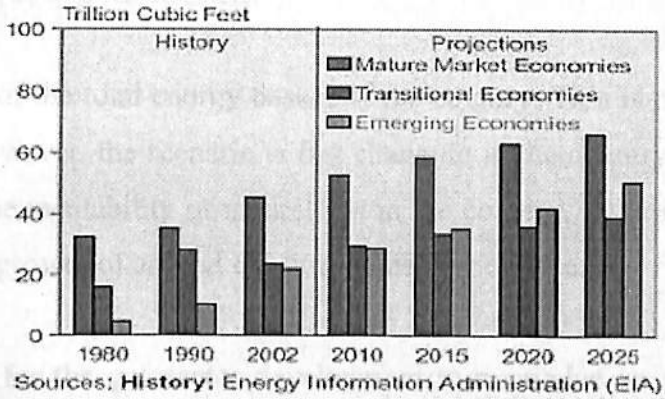


Fig 1.2 World Natural Gas Availability

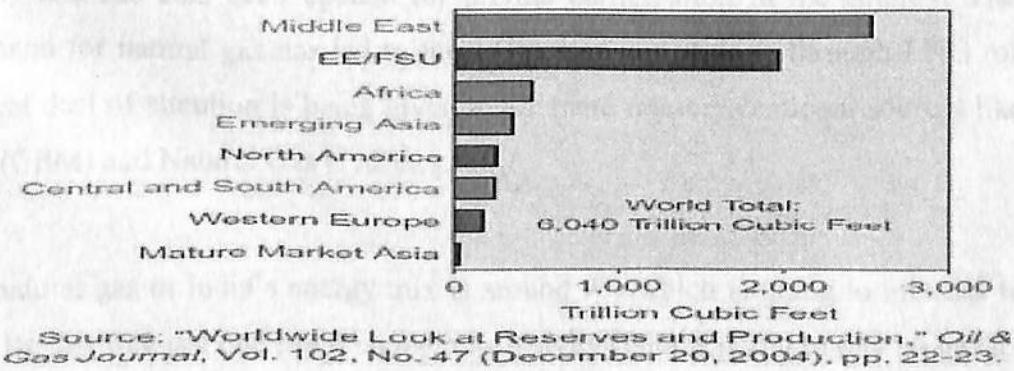


Fig 1.3 Worldwide reserves and production

1.3 NATURAL GAS SCENARIO IN INDIA

The Indian natural gas market is in the midst of a major shift from a centrally managed system to one with a greater role for market forces. The last thirty years have seen a shift in the global energy fuel mix towards an increased role for natural gas. Attractive for its cleaner and more efficient combustion relative to other fossil fuels, gas has assumed a significant role in power generation, industrial applications, residential heating and in some cases as a transport fuel as well.

Natural Gas is emerging as the preferred fuel. India's Gas Demand is increasing at a rapid pace. India's Supply options need a realistic assessment. Pricing of gas provides a challenge for India. When compared to mature natural gas (NG) based economies like Japan, Korea, and the United States, India is a relatively new entrant. However, the increasing significance of the fuel in the Indian context can be gauged from the fact that, by 2025, the country is expected to rival both China and Japan in having the largest NG demand in Asia. Demand in each of these countries is expected to be in the range of 350 MMSCMD.

Gas occupies about 8.5% of the total energy basket of the country. This is much lesser than the world average of 24%. However, the scenario is fast changing in the country, largely because of the expected increase in the availability of natural gas in the country. India is a growing market and has seen an economic growth of around 6% during the past decade.

Emphasis has been given for the gas sector development to maximize its share in the overall energy basket to meet economic growth target of 8% every year. This sector has been given the highest priority and has also been opened for private participation in the country. The large emerging demand for natural gas has led to the process of gas imports through LNG route. In addition, a great deal of attention is being given to alternate non-conventional sources like Coal Bed Methane (CBM) and Natural Gas Hydrates.

The share of natural gas in India's energy mix is around 9% which is going to increase to 20% by year 2025. By this forecast one can imagine how heavily India is going to rely on gas for their source of energy.

	World	India
Energy Consumption (MTOE)	10878	423 5th Largest Energy Consumer
Energy Mix (%)		
Coal	28.4%	56.2%
Oil	35.8%	28.4%
Natural gas	23.7%	8.5%
Nuclear	5.8%	0.9%
Hydro	6.3%	6.0%
Oil & Gas Imports (MTOE) -2006	3264.0	119.0
Growth in Energy (10 yrs)		
Total Primary Energy	2.3%	5.6%
Natural Gas	2.7%	9.4%

INDIA – A FAST GROWING ENERGY MARKET

Source : BP Statistical Review of World Energy (June 2007)

Table 1.2 Comparison of Indian natural gas scenario with world

1.3.1 NATURAL GAS DEMAND IN INDIA

India is one of the largest Energy consumers in the world. Gas consumption is always at rise since early 1980's. India is emerging gas markets, mainly because of shift of fertilizer industries towards gas from Naphtha / fuel oil for their feed stock. Power sector is also a major reason for India to emerge as a major gas market in the world, because power sector is using large quantity of gas for their power production. Another major driver for natural gas consumption would be city gas. Many cities are taking up CNG program for their transportation, which is going to surge in natural gas demand by huge margin. Delhi and Mumbai is already under CNG umbrella. Rajasthan, Gurgaon, Noida are also taking up CNG program. PNG is also a part of city gas, which is also going to affect the demand for natural gas.

The demand for natural gas will also depend on its pricing mechanism too. As natural gas is going to replace traditional fuels, so price of natural gas should be kept below the price of existing consumed fuel. Then only the natural gas can substitute the alternate fuels.

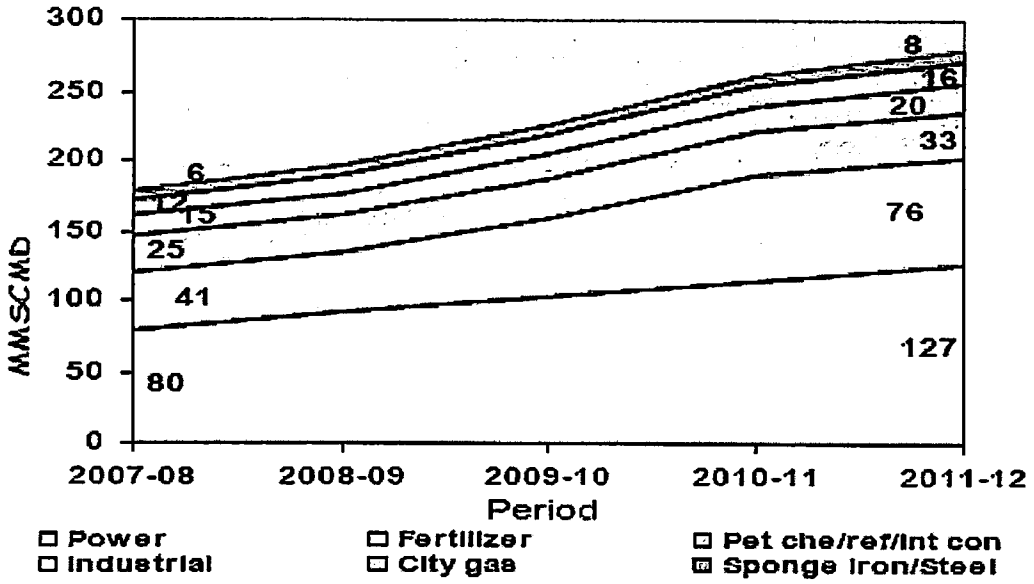


Fig 1.4 Sector wise demand of Natural Gas

Gas demand during XI Plan (2007-2012)

Power Sector

The Power sector would continue to be one of the major consumers of natural gas. The Ministry of Power has set a target of 70,000 MW generation for the XI Plan period ending 2012. The current thermal power generation is about 86,015 MW of which 16 % (13,692 MW) is gas-based. Ministry of Power has indicated that the requirement of gas for gas-based power plants, which would be definitely coming up during the XI Plan period with a capacity of 1889 MW, would be 7.5 MMSCMD. In addition, gas-based power plants, with a total capacity of 12700 MW, are also expected to come up during XI Plan, which would require around 50.82 MMSCMD gas. Thus, the anticipated additional requirement of gas would be 58.3 MMSCMD.

The present requirement of gas for the existing gas-based power plants is 68.18 MMSCMD. Adding gas requirement of 7.50 MMSCMD and 50.82 MMSCMD, as explained in the above paragraph, the total likely gas requirement by the end of XI Plan period is 126.50 MMSCMD. Assuming that the gas requirement increases in the same proportion every year, the projected gas demand for the Power sector for the XI Plan period would be as under:

	2007-08	2008-09	2009-10	2010-11	2011-12
Gas Demand (Power Sector)	79.7	91.2	102.7	114.2	126.50

Table 1.3 Demand in Power Sector

Fertilizers Sector

It has been well established that natural gas is the most cost-effective fuel vis-a-vis other liquid fuels for fertilizer plants. During the year 2004-05, gas-based fertilizer (urea) production accounted for 66% of the total fertilizer production. Naphtha and FO/LSHS based production accounts for the balance 34%. Requirement of gas for fertilizers sector is expected to increase in the years to come, not only for meeting the current shortfall being faced by the existing gas-based urea units, but also on account of conversion of Naphtha and FO/LSHS based units to NG/LNG, de-bottlenecking of existing urea units, setting up of new urea units, expansion of existing urea units and revival of closed urea units. All non-gas-based urea units will be converted to gas within the next three years. Under the above scenario, the total requirement of gas for the fertilizer sector by the end of XI Plan period is expected to be 76.26 MMSCMD. The break-up of gas requirement year wise and the corresponding production capacity of urea are given below:

	2007-08	2008-09	2009-10	2010-11	2011-12
Urea Production Capacity (Lakh tones)	226.16	226.16	259.66	329.35	329.35
Gas Demand (MMSCMD)	41.02	42.89	55.90	76.26	76.26

Table 1.4 Demand in Fertilizer sector

City Gas Sector

This is another sector which has a high growth potential. With the expected growth in the gas supply and the simultaneous creation of gas inter-state transmission infrastructure in India, this sector is bound to grow in the XI Plan period. With the emphasis on clean environment, this sector would get the necessary thrust in the coming years. In line with this, various players,

primarily led by GAIL, have drawn up ambitious plans to roll out city gas infrastructure across a number of cities in the country. The current demand estimate in this sector is about 11 MMSCMD in 2006-07 and 12.08 MMSCMD in 2007-08. Assuming a conservative annual growth of 8 percent, the demand would go up to about 12.93 MMSCMD, 13.83 MMSCMD, 14.8 MMSCMD and 15.83 MMSCMD in 2008-09, 09-10, 10-11 and 11-12 respectively.

Petrochemicals/Refineries/Internal Consumption and Sponge Iron/Steel and other industries

The current demand as per the industry estimates in the Petrochemicals/Refineries and Internal Consumption (of Gas Industries) sectors is about 25.37 MMSCMD. An annual growth rate of about 7 percent is assumed during, which would result in a demand of 33.25 MMSCMD by the terminal year of the XI Plan.

Similarly, the sponge iron/steel sector is also expected to grow at the same rate of 7 percent from the current level of 6 MMSCMD, reaching a level of 7.86 MMSCMD by the terminal year of the XI plan.

Demand of Natural Gas in MMSCMD

SECTOR	2007-08	2008-09	2009-10	2010-11	2011-12
Power	80	91	103	114	127
Fertilizer	41	43	52	80	79
City Gas	12	13	14	15	16
Industrial	15	16	17	18	20
Petrochemicals/ Refineries/ Internal Consumption	25	27	29	31	33
Sponge Iron/ Steel	6	6	7	7	8
Total	179	196	222	265	283

Table 1.5 Natural Gas Demand in India

The significant potential for NG demand especially in the context of India's projected GDP growth above 8 percent is being driven by the following key factors:

• The share of natural gas in India's energy basket is only around 9 percent as compared to the world average of around 24 percent. More than 50 percent of NG volume goes to sectors where it is a substitute to petroleum products and the rest goes to the power sector where it substitutes coal. In this context, NG volume in the country will partly be driven as a substitute to petroleum products because it is cheaper and cleaner. In addition, reforms in the power sector would also encourage NG to be used as a cleaner substitute to coal in the long term. The share of NG in the fuel mix is expected to go up from the present 8.8 percent levels to 22 percent in 2031-32.

• Per capita consumption of NG in India is currently amongst the lowest in the world; being at 29 cu m as compared to a world average of around 538 cu m.

• Demand for NG (at more than 120 mmscmd) in the country has far outstripped supply (about 75 mmscmd), and there has an increasing trend towards emergence of new NG demand as well as conversion from existing fuels to NG.

1.3.2 NATURAL GAS SUPPLY IN INDIA

We have seen that our natural gas demand is increasing day by day. With coming years demand is going to be stronger. To keep pace with demand, gas supply has to be regular and consistent.

Overall Gas Supply projections during XI Plan (2007-2012)

The supply projected by ONGC and OIL in the Plan period is expected to fall from 57.28 MMSCMD in 2007-08 to 51.08 MMSCMD in 2011-12. Supply from Private players/JVs is expected to increase from 23.26 MMSCMD to about 57.22 MMSCMD in 2011-12. This increase from private players is primarily due to the 40 MMSCMD gas supply addition from RIL from 2008-09 onwards. DGH had then projected expected additional supplies of 20, 30 and 40 MMSCMD from RIL fields in 2009-10, 2010-11 and 2011-12 respectively and 54 MMSCMD from GSPC in each of the above years. However, later DGH has increased the expected availability of natural gas from KG D/6 blocks to 80 MMSCMD. DGH has also indicated that the anticipated availability of gas from GSPC fields would be 4.5 MMSCMD by 2011-12.

In the table below, the gas availability which is confirmed by DGH is shown as (B) and is the basis of the conservative scenario. The gas availability expected, but which is yet to be certified by DGH, is shown as (C) and is the basis of the optimistic scenario in the table below:

Source	2007-08	2008-09	2009-10	2010-11	2011-12
ONGC + OIL (A)	57.28	58.42	55.69	54.67	51.08
Pvt./JVs (As per DGH) (B)	23.26	61.56	60.28	58.42	57.22
Projected Domestic Supply (A+B)	80.54	119.98	115.97	113.09	108.30
Additional Gas Anticipated (C)			74	84	94
Total Projected Supply Conservative Scenario (A+B)	**80.54**	**119.98**	**115.97**	**113.09**	**108.30**
Total Projected Supply Optimistic Scenario (A+B+C)	**80.54**	**119.98**	**189.97**	**197.09**	**202.30**

Table 1.6 Natural Gas Supply in India

Looking at the overall demand projections and even the optimistic scenario of expected domestic supplies, it is very clear that there would be a supply shortfall. Therefore, there is a need to step up imports in the coming 5 years. There is already an import of LNG to the tune of 18 MMSCMD by PLL at Dahej. The 5 MMTPA Dahej terminal of PLL is operating at full capacity.

The Hazira terminal of Shell with a capacity of 2.5 MMTPA is also operational. The Dahej terminal is set to expand to 10 MMTPA by 2010-11. Besides, the planned Kochi terminal of PLL with a capacity of 2.5 MMTPA (expandable to 5 MMTPA) is expected by 2010-11. The 5 MMTPA Dabhol terminal is projected to be fully operational by 2009-10. To begin with, the supplies would be 1.2 MMTPA, which would increase to 2.1 MMTPA in 2008-09 to cater to the Dabhol Power Plant. This terminal would also enable a merchant sale volume of 2.9 MMTPA in 2009-10 when long term LNG is contracted. When LNG terminal at Mangalore is taken up, 1.25 MMTPA imports could be expected by 2011-12. Given this scenario, the LNG supply is

projected to reach a level of 23.75 MMTPA by the year 2011-12 (Potentially it can add up 83.12 MMSCMD supplies at full capacity). The overall LNG projections are given below:-

LNG Supply Source	2007-08	2008-09	2009-10	2010-11	2011-12
Dahej	5.00	5.00	7.5	10.00	10.00
Hazira	2.50	2.50	2.50	2.50	2.50
Dabhol	1.20	2.10	5.00	5.00	5.00
Kochi	-	-	-	2.50	2.50
Mangalore	-	-	-	-	1.25
Total LNG Supply (MMTPA)	**8.70**	**9.60**	**15.00**	**20.00**	**23.75**
Total LNG Supply (MMSCMD)	**30.45**	**33.60**	**52.50**	**70.00**	**83.12**
Assumption 1) Hazira expansion to 5.0 MMTPA is not considered in XI Plan. 2) Mangalore terminal is expected to be partially commissioned in 2011-12					

Table 1.7 Total LNG supply sources in India

The LNG option would to a great extent augment the indigenous supplies to meet the demand shortfall. Given the two scenarios of indigenous supply, the total supply, including LNG, is expected to increase from 110.99 MMSCMD in 2007-08 to a level of 191.42 MMSCMD in 2011-12 under conservative scenario. Under the Optimistic Scenario, the total gas supply is expected to increase from 110.99 in 2007-08 to 285.42 MMSCMD in 2011-12.

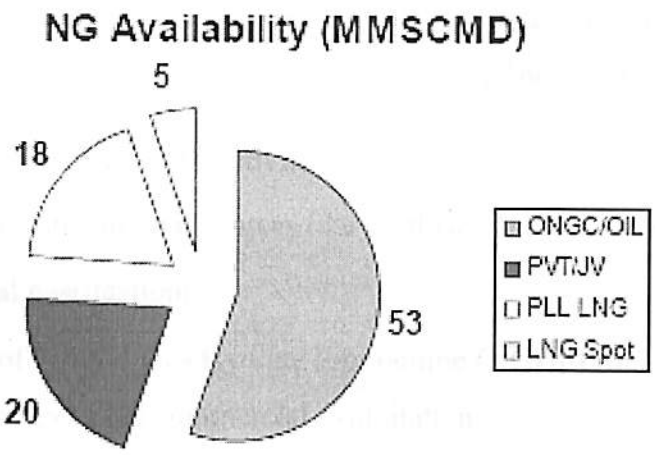


Fig 1.5 Natural Gas Availability in India

1.3.3 NATURAL GAS SUPPLY DEMAND GAP IN INDIA

It is expected that there would be a demand - supply gap (shortfall in supply) to the extent of 68.18 MMSCMD in 2007-08 which would fall to 43.06 MMSCMD in 2008-09 in both the scenarios. From this level, the gap would increase steadily to 88.01 MMSCMD by 2011-12 in the conservative scenario, whereas under the optimistic scenario, the gap would by and large be bridged from 2009-10 onwards and there is expected to be a demand-supply balance during the last 3 years of the XI Plan period. The overall demand-supply balance is presented below:

Overall Gas Demand Supply projection during XI Plan					
Supply	**2007-08**	**2008-09**	**2009-10**	**2010-11**	**2011-12**
Total Supply Conservative Scenario	110.99	153.58	168.47	183.09	191.42
Total Supply Optimistic Scenario	110.99	153.58	242.47	167.09	285.42
Demand (MMSCMD)	179.17	196.64	225.52	262.07	279.43
Demand Supply Gas I	68.18	43.06	57.05	78.98	88.01
Demand Supply Gap II	68.18	43.06	-16.95	-5.02	-5.99

Table 1.8 Overall Gas demand supply projection

Government of India has adopted a multi-pronged strategy to augment gas supplies and bridge the gap between supply and demand for the domestic market. These cover:-

a. Intensification of domestic E&P activities;

b. Exploitation of unconventional sources like Coal Bed Methane (CBM);

c. Underground coal gasification;

d. Implementation of Natural Gas Hydrate Programme (NGHP) for evaluation of hydrate resources and their possible commercial exploitation;

e. LNG Imports

f. Gas sourcing through transnational gas pipelines.

Demand Supply Gap (MMSCMD)				
Years		2007-08	2009-10	2011-12
DEMAND		179	222	283
ONGC + OIL Supplies		57	56	51
Private / JVs Supplies		23	60	57
Total Gas Supplies		80	116	108
LNG Terminals	Dahej	18	18	18
	Dahej Expansion	0	9	18
	Hazira	9	9	9
	Kochi	0	0	18
	Dabhol	4	18	18
	Ennore	0	0	?
	Mangalore	0	0	4
Total LNG Imports		31	54	85
Total LNG + Domestic Gas		111	170	193
GAP		68	52	90

Table 1.9 Demand Supply gap in India

1.3.4 NATURAL GAS CONSUMPTION PATTERN IN INDIA

Presently, fertilizers and power sectors continue to be the major consumers of natural gas at 30% and 41% respectively. They consume about 26% and about 47% of the APM gas respectively, and about 35% each of the market priced gas sold in the country. PMO has directed that the fertilizers sector should get the highest priority in allocation of natural gas. It has also been directed that the power sector should be encouraged to rely more on coal for new capacities.

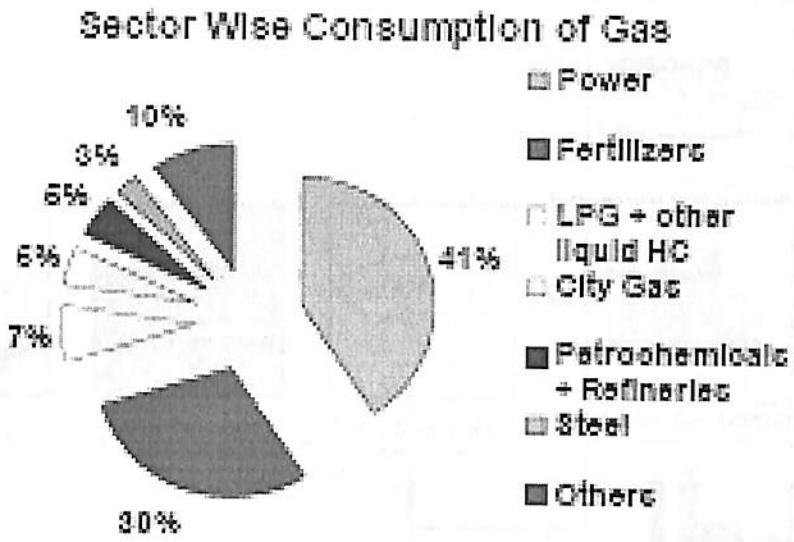


Fig 1.6 Sector wise consumption of Gas

India consumes nearly 110 MMSCMD of gas. Bulk of the gas is consumed by western part of the country which totals to be 65% of total consumption. Eastern part of the country consumes least amount of gas as this part of the country mostly relies on coal as source of energy.

1.4 EVOLUTION OF NATURAL GAS MARKET

1.4.1 TRADITIONAL GAS MARKET

Traditionally there was one gas producer, one gas pipeline company, one local distributor. Local distributor distributes gas to commercial, industrial and domestic customers according to the requirement and Government direction. All these roles were also performed by single company also. Figure 3.1 shows how gas reaches the end customers after production.

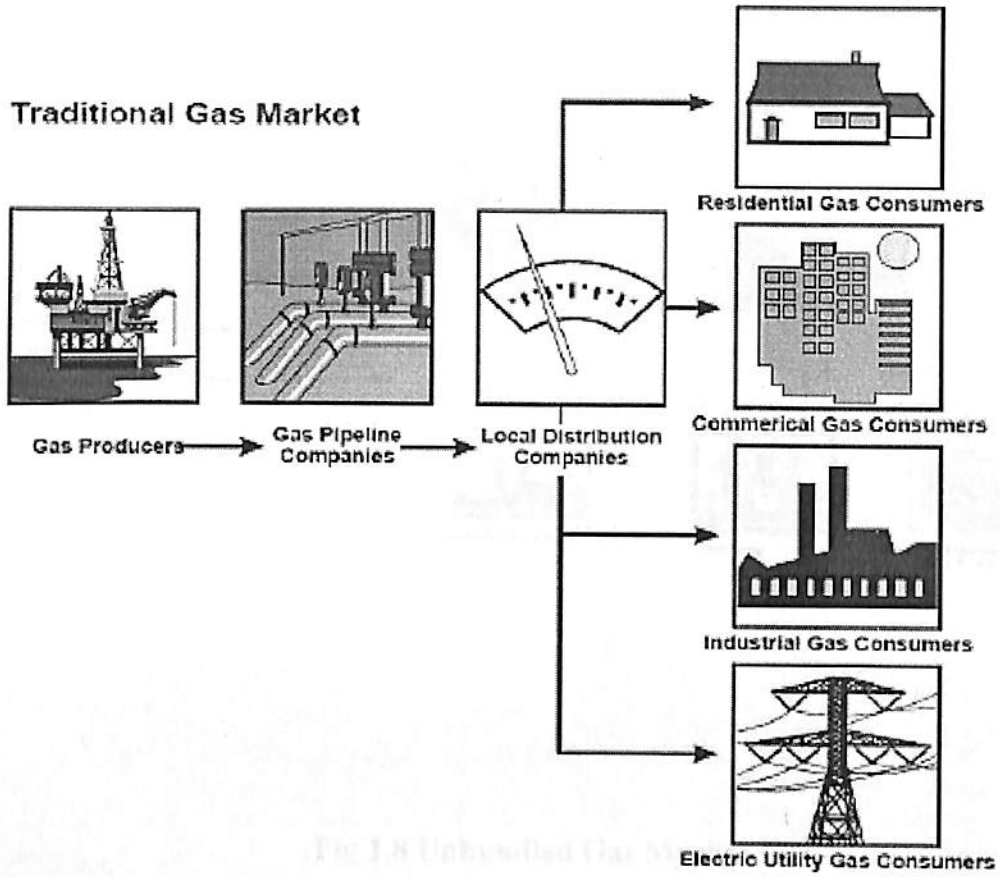


Fig 1.7 Traditional Gas Market

1.4.2 UNBUNDLED GAS MARKET

The modern Gas market is evolving to maturity. If whole gas market is unbundled, gas market will be matured and competitive. All the works involved in the gas market starting from production to distribution are performed by different companies. Gas producer can directly sell the gas to gas distributor and to the consumers. Producers can sell the gas through gas marketer to consumers also. The following figure shows the unbundled gas market.

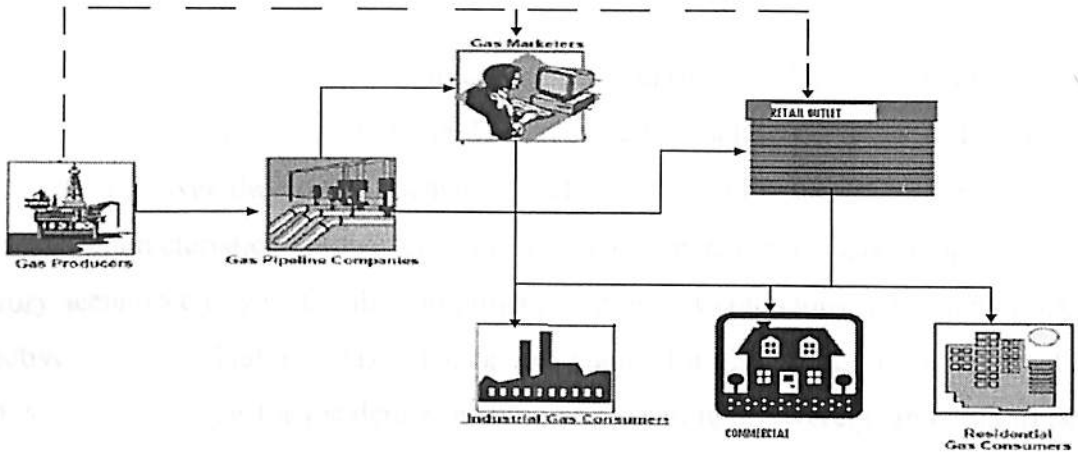


Fig 1.8 Unbundled Gas Market

1.5 MAJOR CHALLENGES OF INDIAN GAS INDUSTRY

- Establishment of price acceptance across sectors including Power
- Pursue Deep Sea, Coal gas, Gas Hydrates technologies
- Emphasis on imports through LNG and Transnational pipelines
- Creating infrastructure
- Institutional support for training to create trained manpower pool
- Prioritization of gas uses
- Explore and develop new fields
- Investing in developing gas fields across frontiers

CHAPTER 2: CITY GAS DISTRIBUTION – AN OVERVIEW

Over the years Natural Gas (NG) has emerged as a 'fuel of choice' across the world. A clean and efficient fuel Natural Gas presents a viable substitute for traditional fossil fuels, namely oil and coal, as concerns over the environmental impact of their continued usage grows and due to its economical characteristics. However with expected increase in gas supply and changing regulatory scenario city gas distribution projects present a tremendous investment opportunity to prospective investors. Natural Gas is the fuel of choice for city energy needs internationally. In OECD countries gas use for residential heating and cooking on average amounts to nearly 25% of the total consumption.

The predominance of Natural Gas as a fuel for city energy purposes internationally is primarily due to three reasons.

- **Natural Gas is a more economical alternative.**
    - Comparing Natural Gas with fuels against which it will be competing in various customer segments within cities namely FO/LSHS for industrial segment, Petrol/Diesel for transport and LPG for commercial and domestic segments, this can be clearly bought out.
    - In the transport segment the fuels are compared based on running cost, CNG is almost three times as economical as the traditional fuels.
    - For industrial customers Natural Gas offers a 20% cost benefit in energy terms while for the domestic segment Piped Natural Gas (PNG) presents a savings opportunity of almost 17% on the monthly bill.
- **Natural Gas is a 'clean' fuel.**
    - When Natural Gas burns it creates lesser pollutants as compared to traditional fossil fuels.
    - The fuel produces lower amount of CO_2 but the real difference lies in the amount of NO_2, SO_2 and particulates, which are one-tenth the amount created by other fuels.
- **Natural gas as a fuel is extremely efficient.**
    - When the entire cycle of producing, processing, transporting and using energy is considered, natural gas is delivered to the consumer with a "total energy efficiency" of about 90 percent, compared with about 27 percent for electricity.

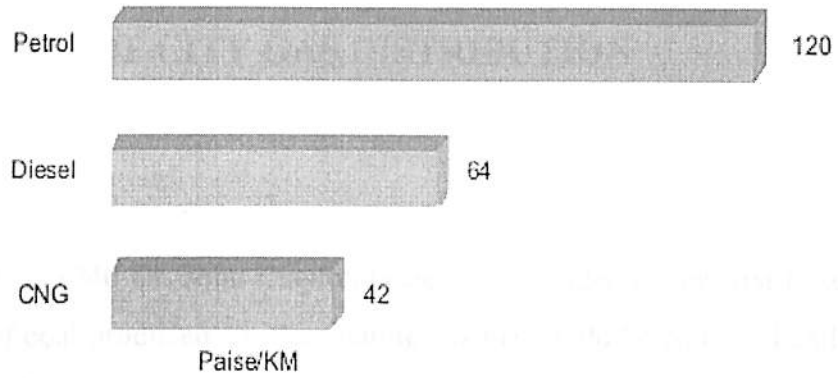


Fig 2.1 Comparison of CNG prices with other fuels

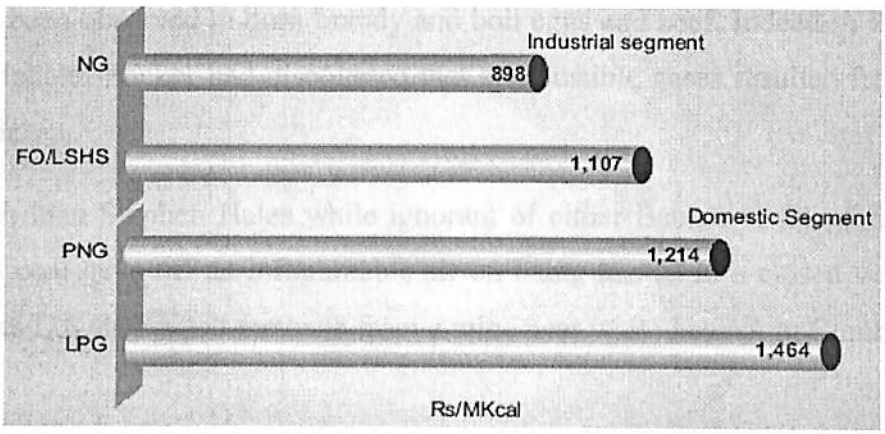


Fig 2.2 Comparison of Natural Gas prices with other fuels in industrial and domestic segment

	(Emissions in gm/100 km)					
Fuel	CO2	UHC	CO	Nox	Sox	PM
Petrol	22000	85	634	78	8.3	1.1
Diesel	21000	21	106	108	21	12.5
LPG	18200	18	168	37	0.4	0.3
CNG	16275	5.6	22.2	25.9	0.2	0.3

Source : CRIS Infac

Table 2.1 Comparison of emissions from various fuels

2.1 EVOLUTION OF CITY GAS DISTRIBUTION

2.1.1 WORLD HISTORY

COAL GAS

On 23rd December, 1740 Dr. John Clayton became recognized as the first to record the fact that the distillation of coal produced an illuminating gas that could be collected and stored for further use. More than 50 years ago he distilled coal in a retort or closed vessel placed in an open fire, collected the resultant gas in bladder and amused his dinner guests by lighting the gas as it escaped. His experiment began around 1684 when he learned that water near Wigan in Lancashire has been observed to burn brandy and boil eggs and beef. Indeed in 1681 a professor from Munich, Johann Backer had discovered that combustible gases resulted from heating coal in absence of air.

In 1727 English man Stephen Hales while ignorant of either Backer or Clayton's observations discovered that coal gave off an inflammable air on being heated in a closed vessel. About the same time James Lowther piped methane from a mine near white heaven in Cumbria to use as an illuminant.

In 1760, George Duxon heated coal in kettle and lit the gas at the end of a pipe attached to spout but abandoned any further experiment after an explosion in his pilot plant. These few examples suggest that the age of gas illumination had finally dawned in Europe by the eighteenth century.

William Murdock the first to study gas making from various types of coal under different conditions became resident agent from the Boulton and Watt mining firm in Cornwell. He was regarded as the first to make gas illumination a commercial venture.

PROBLEM WITH COAL GAS

The major problem in early production of gas was purification, but by 1819 this was no longer so. In 1806 Edward Heard discovered that lime helped to remove some of tha poisonous hydrogen sulphide and other sulphur impurities found in coal gas and had obtained a patent for the purification of gas with dry lime, which, with exposure to air after use, could easily be sold for agricultural use.

In the same year, Samuel Clegg had introduced a more popular method- Wet Liming- whereby a bucketful of lime suspended in about fifty gallons of water would purify about 20,000 cubic feet of gas bubbling through it.

John Malam then devised a compact triple purifier on this principle, before improving upon Reuben Phillip's 1817 process for purifying gas by slack lime. Only by about 1850 was time for purification suspended somewhat through F. C. Hill's promotion of Iron- Oxide. This would be several times over with exposure to air and eventually sold as a weed killer. In Ireland it was known as METHER and was experted from Westmeath to London as late as 1950s.

NATURAL GAS

Gas wells were known to exist in Japan as early as A.D 615 and China in A.D 900 and although western deep drilling may be viewed as an importation from China. The origin of modern Natural Gas industry undoubtedly lies with US. Here in 1821, some forty six years after George Washington described a burning spring on a stretch of land granted to him by General Andrew Lewis in 1775, the first utilization of gas occurred- some boys playing on the bank of the Canada way Creek accidentally ignited a seepage of gas and thereby encouraged the citizens of Fredonia to drill a well and pipe the gas to nearby residences. Thirty seven years later the gas was still going strong. So, the Fredonia Gas Light and Water works was established to become the world's first Natural Gas Corporation. Natural Gas was odorized in 1885, sold by meter in 1891, liquefied by 1940 and piped to markets thousands of mils distance by the 1950s. Clearly US had lead the way in regard to the distribution of Natural Gas as Britain had in regard to the traditional gas manufacturing industry.

2.2 WHAT IS A CITY GAS DISTRIBUTION NETWORK?

"City or local natural gas distribution network" – means an interconnected network of gas pipelines and the associated equipment used for transporting Natural Gas from a bulk supply high pressure transmission main to the medium pressure distribution grid and subsequently to the service pipes supplying natural gas to domestic, industrial, commercial, and CNG stations situated in a specified geographic areas. High pressure and medium pressure networks are designed such that supply to any consumer is possible from either side. These networks design gas storage for maximum survival period. City Gas Distribution networks consider safety at all stages. They balance growth of consumer sectors, especially those cross subsidizing each other. City Gas Distribution mainly consists of:

- COMPRESSED NATURAL GAS (CNG)
  - AUTOMOBILES
- PIPED NATURAL GAS (PNG)
  - DOMESTIC
  - COMMERCIAL
  - INDUSTRIAL

2.2.1 CITY GAS DISTRIBUTION MARKET SEGMENTS

CGD Segments and applications		
Industrial Retail	Direct Firing	Furnaces, Ovens, Dryers
	Indirect Heating	Boilers and Generator
	Cooling	Vapour Absorption Chillers
	Power / Cogeneration	Gas Turbine, Micro Turbine
Residential and Commercial	Cooking, Hot Water, Space Heating and Cooling, Micro Power, Fuel Cell	
Transportation		Compressed Natural Gas

Table 2.2 CGD Market Segments

Application of Natural Gas in Commercial & Industrial segment

CHEMICAL INDUSTRY
• Steam generation
• Heat Exchange
• Extraction
• Washing
• Vaporization
• Distillation
• Preheating and Drying

TEXTILE INDUSTRY
• Fabric
• Yarn drying
• Bleaching
• Dying
• Cleaning
• Washing
• Ironing

PAPER/FOIL WOOD PROCESSING
• Packing wood & veneer drying
• Chipboard manufacturer
• Wood waste incineration
• Charcoal drying

LEATHER INDUSTRY
• Hanging dryers
• Rolling dryers
• Hot water & steam boilers
• Skin toning equipments

METAL INDUSTRY
• Powder coating
• Aluminum extrusion
• Smelting
• Enameling
• Plating
• Washing
• Drying
• Heat treatment plant
• Forging/castings

QUARRYING INDUSTRY
• Ceramic industry
• Glass industry
• Building dryers
• Asphalt plant
• Hot mix plant

HOTEL INDUSTRY
• Steam generation
• Hot water boilers
• VAM's (Air conditioning)

AUTOMOBILE INDUSTRY
• Paint booth
• Heat treatment plant
• Forging/castings

FOOD INDUSTRY
• Baking-ovens
• Deep fat fryers
• Spray dryers
• Steam boilers
• Distillation equipment
• Brewing

WASTE UTILIZATION
• Waste incineration of harmful substances

2.3 WHAT IS CNG?

Compressed Natural Gas (CNG) is a substitute for gasoline (petrol) or diesel fuel. It is considered to be an environmentally "clean" alternative to those fuels. It is made by compressing methane (CH_4) at 200 to 270 bar pressure extracted from natural gas . Argentina and Brazil, in the Southern Cone of Latin America, are the two countries with the largest fleets of CNG vehicles. Conversion has been facilitated by a substantial price differential with liquid fuels, locally-produced conversion equipment and a growing CNG-delivery infrastructure. In response to high fuel prices and environmental concerns, compressed natural gas is starting to be used in light-duty passenger vehicles and pickup trucks, medium-duty delivery trucks, and in transit and school buses.

CNG and its properties:

CNG is the short form of Compressed Natural Gas. The Natural Gas has less energy density as compared to Liquid Fuel and hence it is Compressed to over 200 Kg/cm^2 (g) pressure to make it CNG for use in the automobile sector. In its natural form it is colourless, odourless, non-toxic and non-carcinogenic. However, this natural gas is mixed with an odorant to add flavor similar to the odour of LPG from a domestic cylinder so as to facilitate detection of its leakage. The typical composition and physical properties of CNG (i.e. Compressed Natural Gas) are as follows:

Typical Composition:

Methane: 92.49%

Ethane: 4.93%

Propane: 1.7%

CO2: 0%

Others: 0.88%

Total : 100%

Physical Properties:

Non-toxic – Natural gas being lead/sulphur free, its use substantially reduces harmful engine emissions. When natural gas burns completely, it gives out carbon dioxide and water vapour - the very components we give out while breathing.

Lighter than air – Natural gas being lighter than air, will rise above ground level and disperse in the atmosphere, in the case of a leakage.

Colourless – Natural Gas is available in the gaseous state, and is colourless.

Odourless – The gas in its natural form is odourless, however, ethyl mercaptan is later added as odorant so as to detect its leakage.

2.3.1 WHY COMPRESSED NATURAL GAS?

Health Effect of Vehicular pollution

Major Causes of Vehicular Pollution
70% of total air pollution comes from vehicles due to:

- The traffic conditions
- The condition of vehicles
- Fuel used in vehicles

Effects of Vehicular Pollutants

Substance	Health Effect
CO (from gasoline cars, 2-wheelers, 3-wheelers)	Fatal in large doses; aggravates heart disorders; effects central nervous system; impairs oxygen carrying capacity of blood
NO_x (from diesel vehicles)	Irritation of respiratory tract
Ozone	Eye, nose and throat irritation; risk to asthmatics, children and those involved in heavy exercise
Lead (from petrol vehicles)	Extremely toxic: affects nervous system and blood; can impair mental development of children; causes hypertension
HC (mainly from 2-wheelers and 3-wheelers)	Drowsiness, eye irritation, coughing
Benzene	Carcinogenic
Aldehydes	Irritation of eyes, nose and throat, sneezing, coughing, nausea, breathing difficulties; carcinogenic in animals
PAH (from diesel vehicles)	Carcinogenic

Table 2.3 Effects of Vehicular Pollutants

The Environmental Benefits of CNGs

One of the primary reasons for pursuing alternative fueled vehicle technology is to decrease environmentally harmful emissions. It is estimated that vehicles on the road account for 60 percent of carbon monoxide pollution, 29 percent of hydrocarbon emissions, and 31 percent of nitrogen oxide (NOx) emissions in the United States. All of these emissions released into the atmosphere contribute to smog pollution, and increase the levels of dangerous ground level ozone. Vehicles also account for the emission of over half of all dangerous air pollutants, and around 30 percent of total carbon emissions in the U.S., contributing to the presence of 'greenhouse gases' in the atmosphere.

The environmental effects of NGVs are much less detrimental than traditionally fueled vehicles Natural gas vehicles, when designed to run on natural gas alone, are among the cleanest vehicles in the world. In fact, the Honda Civic GX, released in 1997, has the cleanest internal combustion engine ever commercially produced. This natural gas powered automobile emits so few pollutants that in some large cities the emissions from the car are cleaner than the air surrounding it! California, with some of the tightest clean air standards anywhere in the United States, has recognized selected natural gas vehicles as meeting and exceeding its most stringent standards, including low-emission vehicle (LEV), ultra-low emission vehicle (ULEV), and super-low emission vehicle (SULEV) standards.

CNG vehicles are much cleaner burning than traditionally fueled vehicles due to the chemical composition of natural gas. While natural gas is primarily methane, gasoline and diesel fuels contain numerous other harmful compounds that are released into the environment through vehicle exhaust. While natural gas may emit small amounts of ethane, propane, and butane when used as a vehicular fuel, it does not emit many of the other, more harmful substances emitted by the combustion of gasoline or diesel. These compounds include volatile organic compounds, sulfur dioxide, and nitrogen oxides (which combine in the atmosphere to produce ground level ozone), benzene, arsenic, nickel, and over 40 other substances classified as toxic by the **Environmental Protection Agency.** Dedicated NGVs also produce, on average, 70 percent less carbon monoxide, 89 percent less non-methane organic gas, and 87 percent less NOx than traditional gasoline powered vehicles.

2.3.2 WORLD SCENARIO

Argentina and Brazil, in the Southern Cone of Latin America, are the two countries with the largest fleets of CNG vehicles. In response to high fuel prices and environmental concerns, compressed natural gas is starting to be used in light-duty passenger vehicles and pickup trucks, medium-duty delivery trucks, and in transit and school buses. CNG has grown into one of the major fuel sources used in car engines in Pakistan, Bangladesh and India.

According to the International Association for Natural Gas Vehicles, Pakistan has the third-largest number of natural gas vehicles. In the Middle East and Africa, Egypt is a top ten country in the world with more than 63000 CNG vehicles and 95 fueling stations nationwide. Egypt was

also the first nation in Africa and the Middle East to open a public CNG fuelling station in January 1996.

During the 1970s and 1980s, CNG was commonly used in New Zealand in the wake of the oil crises, but fell into decline after petrol prices receded. In Germany, CNG-generated vehicles are expected to increase to two billion units of motor-transport by the year 2020. The cost for CNG fuels are 1/3 less than LNG fuels, in Europe. CNG is often measured and sold in Gasoline Gallon Equivalent GGE to help American consumers when comparing to gasoline.

2.3.3 TYPES OF CNG STATIONS:

Four types of CNG stations are:

1. **Mother Station**: Mother stations are connected to the pipeline and have high compression capacity. These stations supply CNG to both vehicles and daughter stations (through mobile cascades). Typically they have the facility of filling all types of vehicles – buses/autos/cars. The Mother station requires heavy investment towards compressor, dispensers, cascades, pipelines, tubing etc.

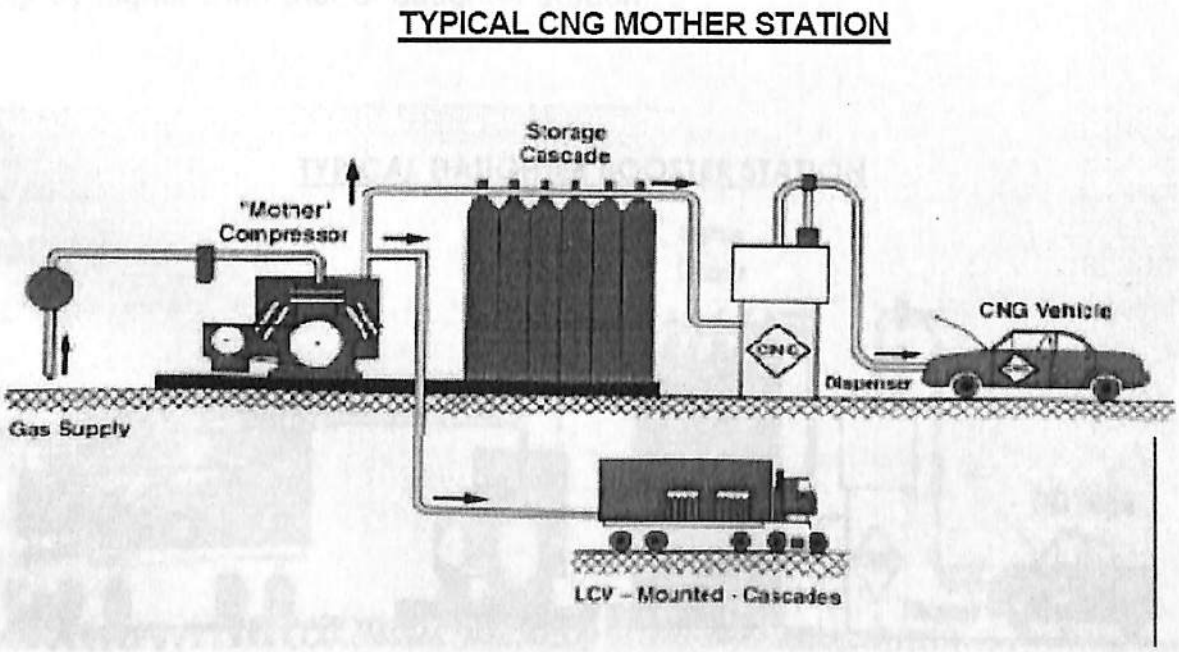


Fig 2.3 Typical CNG Mother Station

2. Online Station: CNG vehicle storage cylinders need to be filled at a pressure of 200 bars. "On line Stations" are equipped with a compressor of relatively small capacity, which compresses low pressure pipeline gas to the pressure of 250 bar for dispensing CNG to the vehicle cylinder. The investment in an online station is midway between daughter station and mother station

3. Daughter Station: The "Daughter Stations" dispense CNG using mobile cascades. These mobile cascades at daughter stations are replaced when pressure falls and pressure depleted mobile cascade is refilled at the "Mother Station". The investment in a daughter station is least among all types of CNG stations. There is reduction in storage pressure at daughter stations with each successive filling. Once the storage pressure drops, the refueling time increases, while the quantity of CNG dispensed to vehicle also decreases.

4. Daughter-Booster Station: Installing a booster compressor can eliminate drawbacks of daughter stations. The mobile cascade can be connected to the dispensing system through a booster. Daughter booster (compressor) is designed to take variable suction pressure and discharge at constant pressure of 200 bars to the vehicle being filled with CNG. The investment in daughter booster station is slightly higher than that of daughter station.

TYPICAL DAUGHTER BOOSTER STATION

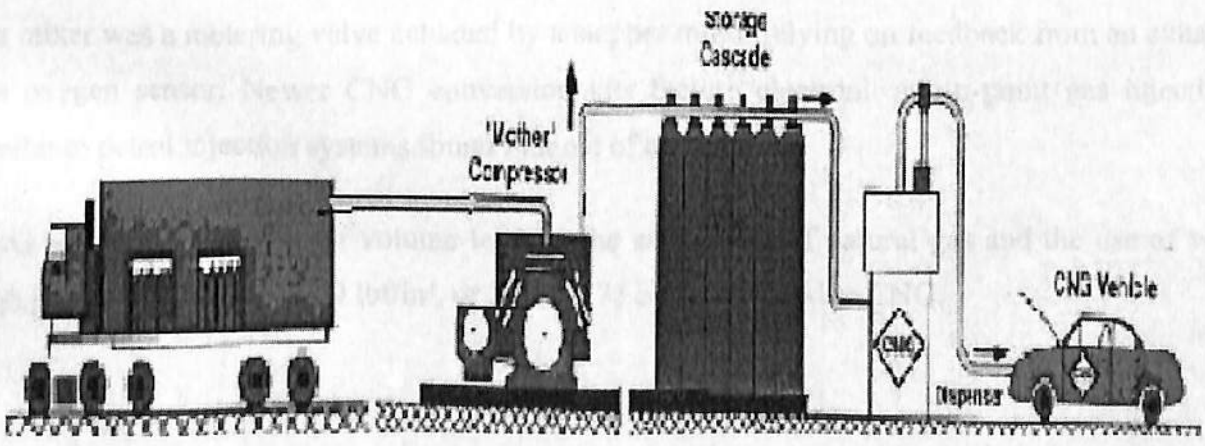


Fig 2.4 Typical Daughter Booster Station

2.3.4 TECHNOLOGY

CNG can be used in Otto-cycle (gasoline) and modified Diesel cycle engines. Lean-burn Otto-cycle engines can achieve higher thermal efficiencies when compared with stoichiometric Otto-cycle engines at the expense of higher NOx and hydrocarbon emissions. Electronically-controlled stoichiometric engines offer the lowest emissions across the board and the highest possible power output, especially when combined with EGR, turbo-charging and intercooling, and three way catalytic converters, but suffer in terms of heat rejection and fuel consumption. A suitably designed natural gas engine may have a higher output compared with a petrol engine because the octane number of natural gas is higher than that of petrol. CNG may be refueled from low-pressure ("slow-fill") or high-pressure ("fast-fill") systems. The difference lies in the cost of the station vs. the refueling time. There are also some implementations to refuel out of a residential gas line during the night, but this is forbidden in some countries.

CNG cylinders can be made of steel, aluminium, or plastic. Lightweight composite (fibre-wrapped plastic) cylinders are especially beneficial for vehicular use because they offer significant weight reductions when compared with earlier generation steel and aluminium cylinders, which leads to lower fuel consumption.

The equipment required for CNG to be delivered to an Otto-cycle engine includes a **pressure regulator** (a device that converts the natural gas from storage pressure to metering pressure) and a **gas mixer** or **gas injectors** (fuel metering devices). Earlier-generation CNG conversion kits featured venturi-type gas mixers that metered fuel using the Venturi effect. Often assisting the gas mixer was a metering valve actuated by a stepper motor relying on feedback from an exhaust gas oxygen sensor. Newer CNG conversion kits feature electronic multi-point gas injection, similar to petrol injection systems found in most of today's cars.

CNG requires a much larger volume to store the same mass of natural gas and the use of very high pressures (3000 to 4000 lbf/in^2, or 205 to 275 bar) compared to LNG.

Use of Natural Gas for powering vehicles

This is accomplished by the following steps:

1. Natural gas is compressed and enters the vehicle through the natural gas dispenser or fill post
2. It flows into high-pressure cylinders that are located on the vehicle.
3. When the driver steps on the accelerator, the natural gas leaves the on-board storage cylinder, passes through the high-pressure fuel line and enters the engine compartment.
4. Gas then enters the regulator, which reduces pressure from up to 3,600 psi to approximately atmospheric pressure.
5. The natural gas solenoid valve allows natural gas to pass from the regulator into the gas mixer or fuel injectors.
6. Natural gas mixed with air flows down through the carburettor or fuel injection system and enters the engine's combustion chambers.

2.3.5 CNG CONVERSION

As we know all types of vehicles can run on CNG by installing CNG kit. Kit is assembling of many components required to run existing vehicle on CNG. There are few basic components which are common in all type of kits, irrespective of the vehicles such as CNG storage cylinder, high pressure tube, pressure regulator, pressure gauge, change over switch, high pressure tube fittings, refueling receptacle and air fuel mixer.

Major components of CNG kit for carburetor fitted petrol vehicle are illustrated below:

1. Pressure Regulator.

2. Petrol Solenoid Valve with manual override switch. (Stops petrol flow when operating on CNG)

3. On-Off valve and refueling connector. (Opens or stops gas flow to the regulator and includes a refueling device)

4. Control Module/Change-over Switch (Electronic control component with fuel selection switch)

5. CNG level Indicator (LED Indicator).

6. Gas Air Mixer.

7. CNG cylinder with valve, vapour bag & bracket

8. Petrol hose

9. Low-pressure gas hose.

10. Ignition advance processor

11. High pressure gas tube

12. Wire harness.

13. NRV in petrol return line.

14. Pressure gauge

2.3.6 SAFETY ASPECTS OF CNG

The following are the safety aspects of Compressed Natural Gas:

- Lighter than air in event of leak it will rise and disperse in atmosphere.
- Unlikely to ignite due to narrow combustible range (5% - 15% concentration in air).
- High ignition temperature (540^0C).
- CNG Cylinders structurally most sound and have passed every severe test.
- A survey on a size of 8,000 vehicles, conducted in USA, reported 34% less injury rates per Vehicular mile travelled.

2.3.7 BENEFITS OF CNG

- The most economical & environment friendly fuel available.
- Though the initial cost of conversion kit may seem to be high, the same can be recovered in less than 2 years because of low operating cost.
- CNG is environment friendly, No cancer causing particulates, less carbon monoxide & hydro carbon emissions, less ground level ozone contamination & Green House gases effects.
- CNG is much safer than Gasoline, diesel fuels or LPG. If released, CNG does not liquefy or accumulate. It dissipates in the air because natural gas is lighter than air & thus less prone to ignite or explode.
- CNG reduces engine wear, more than doubling engine life because CNG burns clean & leaves no carbon deposits.
- CNG offers lower maintenance cost. It is a dry gaseous fuel & does not dilute the lubricating oil, thus saving on oil filters & oil changing. Intervals between tune ups for CNG vehicles are stated to be more than 70,000 km.
- If CNG is used, there is complete freedom from adulteration by solvents, kerosene or any other harmful substance.
- Because CNG is already in a gaseous state, it offers superior drivability even under severe hot & cold weather conditions.
- CNG has high Octane number when compared with Petrol / Diesel which makes it superior in terms of combustion efficiency.
- Per unit of energy natural gas contains less carbon than any other fossil fuel & therefore produces lower CO2 emission per vehicle km travelled.
- World-wide it is believed that Natural Gas costs 1/3rd less than conventional gasoline.

2.4 WHAT IS PNG?

PNG is mainly methane – CH4 with a small percentage of other higher hydrocarbons. The ratio of carbon to hydrogen is least in methane and hence it burns almost completely making it the cleanest fuel. It is procured from the oil / gas wells and transported through a network of pipelines across the country. Piped Natural Gas (PNG) has several distinctions to its credit- of being a pollution-free fuel, easily accessible minus storage troubles, and being available at very competitive rates, are just a few of them.

With PNG you don't need to make any choices, for its characteristics make it the best option for domestic and commercial purposes. No storage problems and stock accounting PNG does not require any storage tank or storage space since it is supplied to you through pipelines. PNG has been positioned to be cheaper than alternative fuels being used viz domestic LPG in case of House Hold, commercial LPG in case of Small Commercial and LPG Bulk & LDO in case of Large Commercial.

2.4.1 SAFETY ASPECTS OF PNG

The combustible mixture of natural gas and air does not ignite if the mixture is leaner than 5% and richer than 15% of the air-fuel ratio required for ignition. This narrow inflammability range makes PNG one of the safest fuels in the world.

Natural gas is lighter than air. Therefore, in case of a leak, it just rises and disperses into thin air given adequate ventilation. But LPG being heavier will settle at the bottom near the floor surface. A large quantity of LPG is stored in liquefied form in a cylinder. With PNG, it is safer since PNG installation inside your premises contains only a limited quantity of natural gas at low pressure i.e. 21 milibar (mbar). On leakage, LPG expands 250 times, which is not the case with NG. Supply in PNG can be switched off through appliance valve (inside the kitchen) and isolation valve (outside kitchen premises), which fully cuts off the gas supply.

2.4.2 BENEFITS OF PNG

Uninterrupted supply-

The source of PNG supply in Delhi is the famous Hazira-Vijaipur-Jagdishpur (HVJ) pipeline of GAIL (India) Limited. PNG offers the convenience of ensuring continuous and adequate supply of PNG at all times, without any problems of storing gas in cylinders.

Unmatched convenience

The domestic consumers have to take upon themselves the trying task of booking an LPG cylinder refill, time and again. And then starts the wait for the deliveryman to deliver the cylinder. Switching over to PNG renders this entire exercise unnecessary. PNG also eliminates the tedious routine of checking LPG refill cylinder for any suspected leakage, or it being underweight, at the time of delivery. Moreover, the user is spared the inconvenience of connecting and disconnecting the LPG cylinder when out of gas. Precious space, occupied by LPG cylinders is also saved.

Economy with PNG

PNG has been positioned to be cheaper than alternative fuels being used viz domestic LPG in case of House Hold, commercial LPG in case of Small Commercial and LPG Bulk & LDO in case of Large Commercial. This is besides the amount you save by avoiding underweight cylinders delivered to you.

A versatile fuel

Natural gas is being used predominantly as a versatile fuel in many major cities catering to domestic and commercial applications, as a cooking fuel, for water heating, space heating, air conditioning, etc.

Environment friendly

Natural gas is one of the cleanest burning fossil fuels, and helps improve the quality of air, especially when used in place of other more polluting energy sources. Its combustion results in virtually no atmospheric emissions of sulphurdioxide (SO2), and far lower emissions of carbon monoxide (CO), reactive hydrocarbons and carbon dioxide, than combustion of other fossil fuels.

In fact, when natural gas burns completely, it gives out carbon dioxide and water vapour. These are the very components that we give out while breathing!

No daily liasioning

The consumer is spared the task of liasioning with oil companies and co-ordinating with them for ensuring the daily supply of fuel, because PNG is supplied directly through pipes. The daily bills, settlements and reconciliation are also avoided as the consumer is billed once a month, and that too as per the meter reading.

No spillage and pilferage

In case of spillage of fuels like HSD and LDO, there are liable to be immense product losses. Also, there are considerable chances of pilferage of these fuels. In case of PNG these losses are invariably done away with, for PNG is supplied through pipes.

Lower maintenance cost

With PNG, soot or ash accumulation and greasy spillages are absent from your appliance. Maintenance costs are, thus, driven down.

2.5 CRITICAL ASPECTS OF CITY GAS DISTRIBUTION PROJECTS

With a growing demand base and increasing supply options City Gas Distribution networks offer a tremendous investment opportunity. However in order to tap this opportunity the developers need to analyze several critical aspects of the project.

- **Demand build-up** - For a city gas distribution project the industrial segment provides the "base load" demand, which can be captured in a shorter time frame. In contrast, buildup of demand in the commercial, transport and residential segments provides better margins but has a higher gestation period. The project roll out must therefore be planned to capture an optimal mix of demand from these segments.

- **Supply** - Input gas price and its terms and conditions are critical for the viability of the city gas distribution project. Existence of Natural gas networks passing by or in proximity of the supply sources from the city limit enhances the project feasibility by reducing the capital and input gas costs.

- **Pricing of delivered gas** - The delivered gas must be priced in such a manner so as to secure a minimum level of profitability for the promoters; while providing adequate incentive to induce targeted customers to shift to Natural Gas. Keeping this in mind Gas should be priced using the 'alternate fuel linked pricing' methodology where Gas is priced at an appropriate discount to alternate fuel prices. For example in PNG the fuel should be priced at a discount to LPG so as to provide the customer with a payback period of less than three years on the expenditure on setting up the connection.

- **Risk factors**- The feasibility of a city gas project is highly sensitive to the demand the company is able to capture, and is thus exposed to **demand risk.** The project is also exposed to **price risk** due to the probable mismatch in the movement of input gas price and selling price. Moreover as the Indian Gas sector does not have a well-developed regulatory framework. Uncertainty exists over issues such as licensing for setting up distribution networks, exclusivity of operator within a distribution zone and role of regulator in pricing of gas. This exposes projects to **regulatory risk.** The project could also be exposed to the residual risk created by the difference in terms and conditions of contracts with the suppliers and the buyers.

2.6 FEASIBILITY ANALYSIS OF CITY GAS DISTRIBUTION PROJECTS

Evaluation of Investment opportunity

The central point for this process is the **market size determination,** which clearly defines the realizable market at various price points for Natural Gas, customer segment wise. This is followed by **project cost estimation** where individual items of capital and operating costs are analyzed. The next step is to analyze the attractiveness of **supply options** for the project based on price, availability, details of the contract etc. Subsequently the **selling price** for each customer

segment is determined based on alternate fuel prices with appropriate discounts. Next identifying various risk classes and the extent to which the project is exposed to these risks creates the **risk profile** of the project. Also ways to mitigate these risks are suggested. Finally the demand, price, cost and risk inputs are combined to undertake a base case **financial feasibility** of the project. Sensitivity analysis is then performed to test its stability.

Framework for Feasibility Analysis of City Gas Distribution Projects

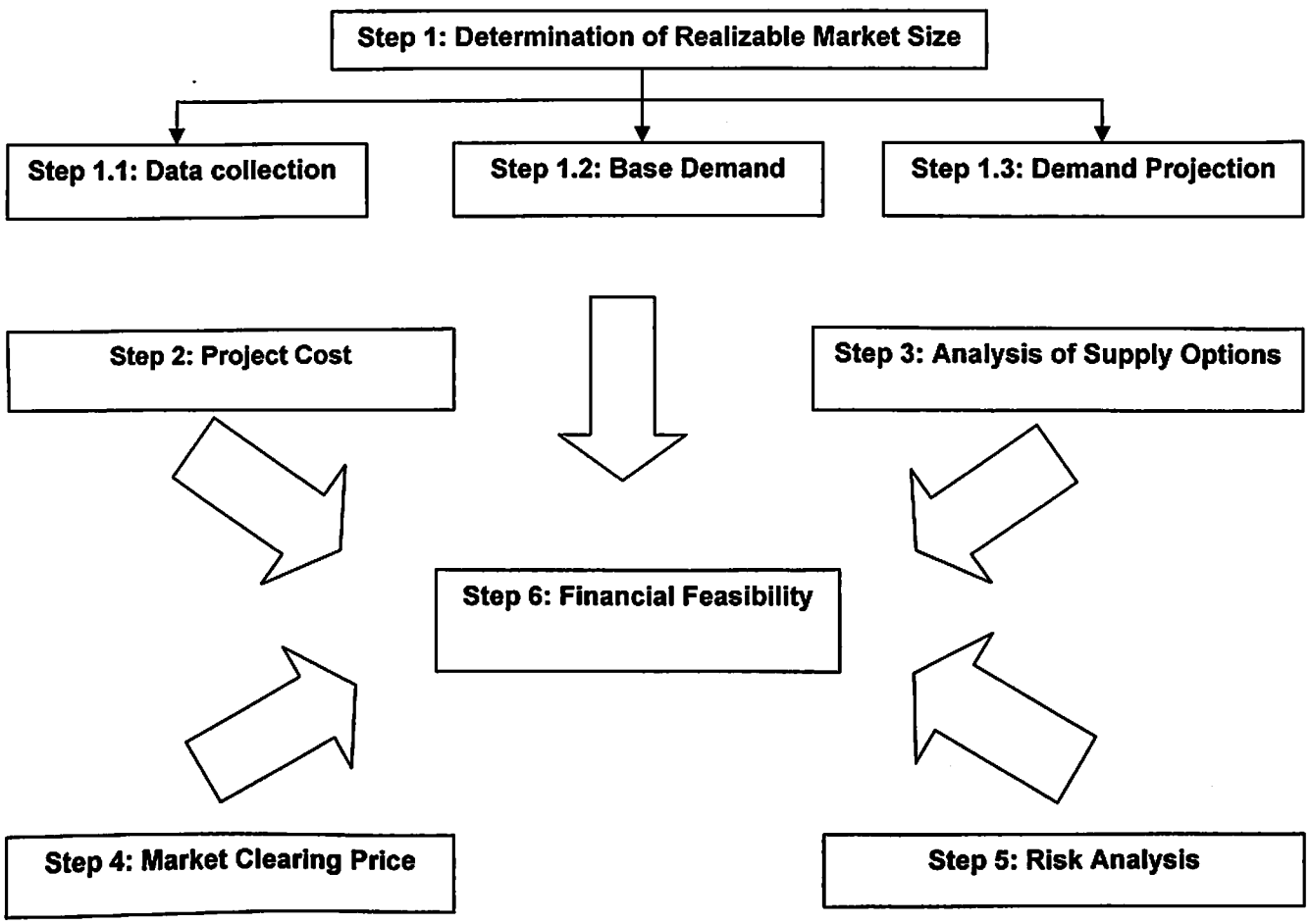


Fig 2.5 Framework for Feasibility Analysis of CGD Projects

Step 1: Determination of Realizable Market Size

Step 1.1: Data Collection

- **Industrial segment:**
  - Identification of nature of industry
  - Fuel consumption
  - Constraints to use of natural gas
  - Willingness to shift
- **Domestic/commercial segment:**
  - Average size,
  - Willingness to shift
  - Average income
- **CNG segment:**
  - Vehicle type
  - Fuel type
  - Average fuel efficiency
  - Willingness to switch

Step 1.2: Base Demand

- **Industrial customers:**
  - Filtering of consumption data based on type of
  - Fuel, size of operation etc.
  - Cost of switchover
  - Demand estimation based on expected
  - penetration level achieved
- **Domestic/commercial segment:**
  - Identification of targetable clusters
  - Demand estimation based on level of expected
  - penetration
- **CNG consumers:**
  - Quantification of benefit of CNG
  - Capital cost estimation of switching

Step 1.3: Demand Projection

- **Industrial segment:**
  - Demand projections based on current demand captured
  - Expected expansions, new additions
- **Domestic/commercial segment:**
  - Demand projection based on urban development
  - Population growth, demographic profile etc
- **CNG segment:**
  - Estimation of penetration level under various vehicle categories
  - Expected growth in vehicles based on past trends

Step 2: Project Cost

- Project Cost estimation based on preliminary project design
- Identification of optimal capital structure
- Identification of required rate of return based on financial costs
- Estimation of operating costs

Step 3: Analysis of Supply Options

- Identification of gas sourcing options
- Comparison based on Security of supply, timeframe, supply quantity, expected price and availability of transmission infrastructure
- Estimation of expected transportation costs
- Terms of the contract

Step 4: Market Clearing Price

- Analysis of existing fuel for each customer segment
- View on likely price scenario of existing fuel
- Capital cost involved in switching to Natural Gas in each segment
- Appropriate discount determination on alternate fuel prices based on desired payback period

Step 5: Risk Analysis

- Identification of risk items under each risk class:
  - Development period risk
  - Construction period risk
  - Operating period risk
  - Market risk-consisting of demand and price risk
  - Regulatory risk
- Suggest risk mitigation measures

Step 6: Financial Feasibility

- Creation of financial model based on demand, price and cost projections
- Analysis of key financial aspects i.e. equity IRR, DSCR
- Sensitivity analysis on assumptions of the base case and effect on key project characteristics like equity IRR etc.

2.7 KEY SUCCESS FACTORS OF CITY GAS DISTRIBUTION

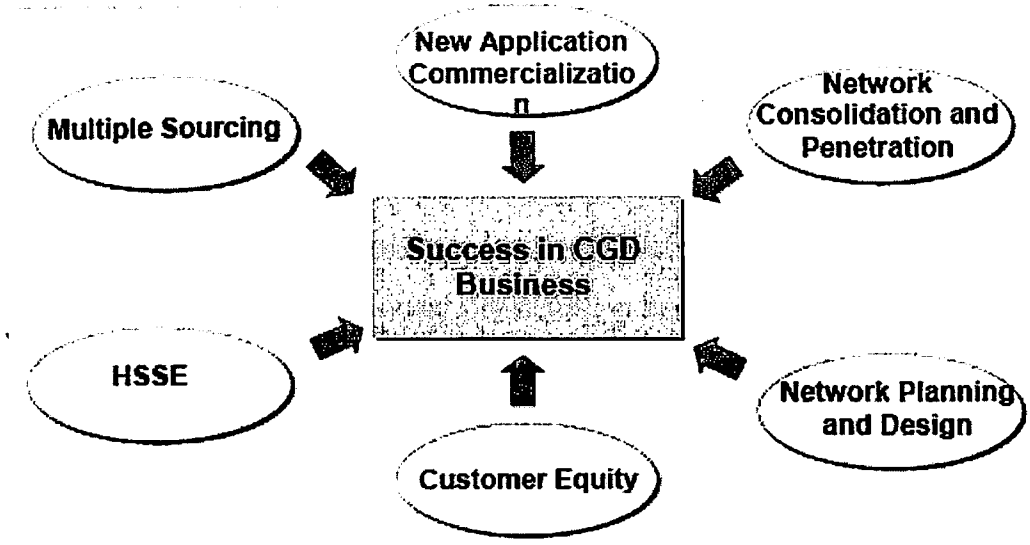


Fig 2.6 Key Success factors of CGD

7. **Multiple Gas Sourcing**

- Continuous gas supply critical for CGD projects
- Gas storage not feasible
    - Minor daily swings managed by line pack
    - Gas holders used in US,UK etc (also in Baroda)
- Multiple sources allows operational flexibility during shutdown, strikes etc
- Multiple delivery points equally essential
- Commingling results in variation of quality of gas

2. New Application Commercialization

Commercialization of CHP segment

- Dedicated team set up
- Customized contracts for CHP requirements
- Brought together customer, engine supplier, equipment supplier etc

CNG – Strategy for growth

- Develop infrastructure for anticipated demand
- Work closely with kit suppliers, distributors, financiers and conversion garages
- Effective branding
- Reduce conversion cost
- Target Four wheeler (cars) and commercial vehicle segment

Other Applications

- Yarn Heat Setting for textile weaving industry commissioned
- Gas Geysers have increased unitary consumption in domestic segment
- Jet dyeing application for Textile Process Houses
- Gas based chilling system for the Diamond industry
- Gas based air conditioners for domestic being developed
- CNG fired two wheelers

3. Network Consolidation and Penetration

Development of New Clusters

- Higher volume growth in new areas
- Industrial development of new areas on back of Gas availability
- Higher utilization of existing assets
- Requires higher investment

4. Network Planning and Design

- Network planning should consider:
  - Robust future load potential
  - Daily and monthly load swings
  - Gas pressure requirements
  - Adequate network redundancy
- Asset integrity should be given paramount importance
- Specialized tools and technical expertise required
  - GIS Mapping of network
  - Network simulation tools

5. Customer Equity

Key factors influencing Customer Equity

- Understanding of customers business
- Communication
- Perception of being a fair operator
- High customer service levels

8. HSSE

People

- Culture
- Behavior
- Systems – Risk Assessments
- Competency

Assets

- Asset Integrity
- Performance Monitoring
- Compliance with BG AIBA process
- Benchmarking

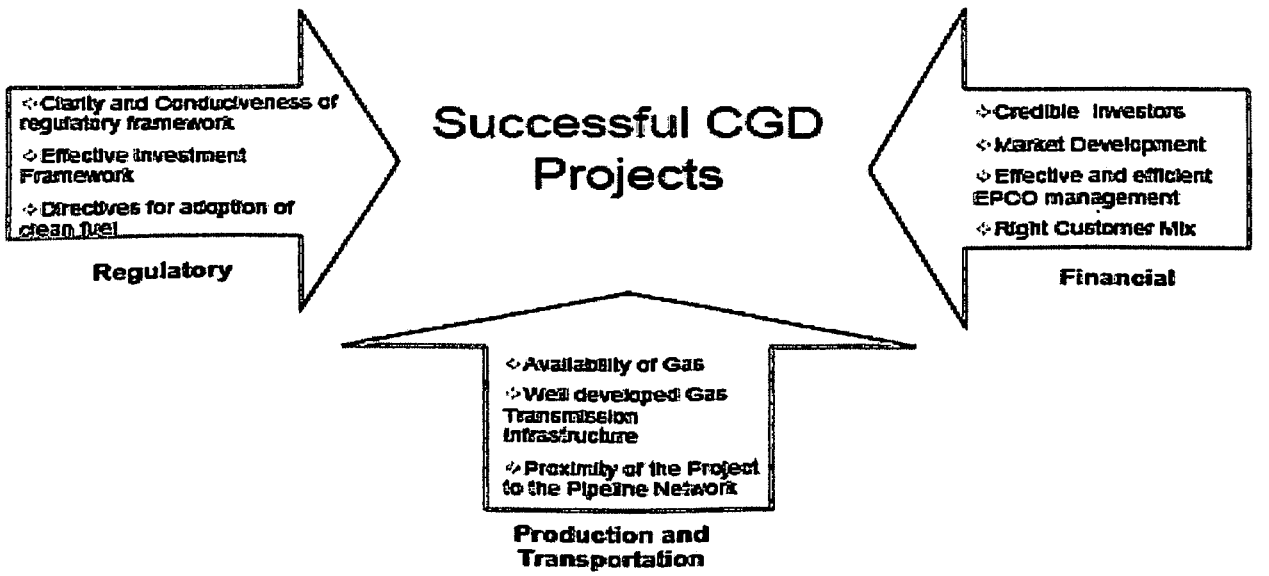


Fig 2.7 Framework for successful CGD projects

CHAPTER 3: CITY GAS OPERATIONS & ECONOMICS

3.1 CITY GAS DISTRIBUTION INFRASTRUCTURE

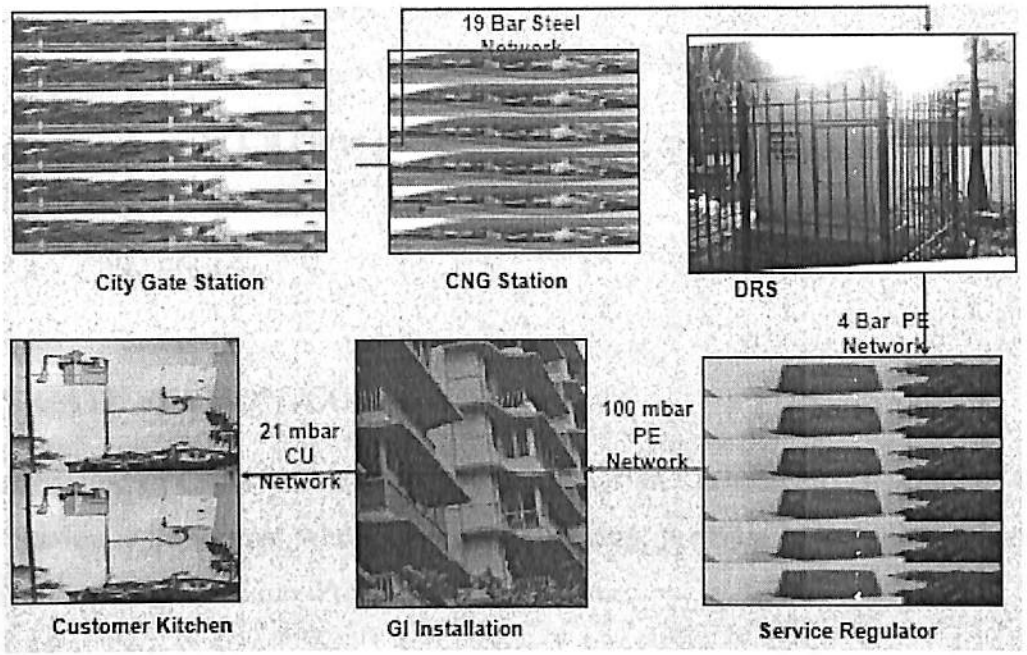


Fig 3.1 City Gas Distribution Infrastructure

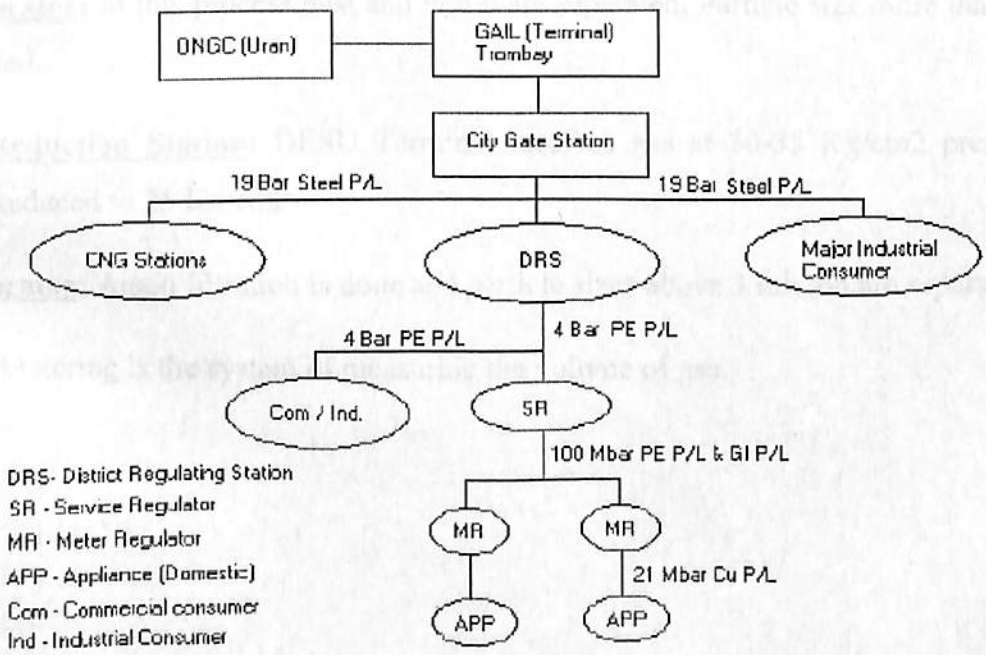


Fig 3.2 Process Description

Major Constituents of CGD are

- **City Gate station**
- **Pipelines**
  - ✓ **Steel Pipelines**
  - ✓ **Poly Ethylene Pipelines**
  - ✓ **GI / Cu Pipes**
- **Regulating Stations**
- **CNG Stations**

3.1.1 CITY GATE STATION (CGS)

CGS is the location of Custody Transfer from Transmission Company to Distribution Company. City Gate Station is a terminal where scrubbing, filtering, pressure reduction and metering and then maneuvering of gas is done. Processes involved are:

Scrubbing: Gas enters a chamber, where gas passes through a cyclonic process and particle size above 40 micron gets settled and rest escapes along with gas to filter separator.

Filter Separator: In this process dust and liquid are separated. Particle size more than 5 micron gets separated.

Pressure Reduction Station: DESU Terminal receives gas at 30-35 Kg/cm2 pressure. This pressure is reduced to 25 Kg/cm2.

Filter Separator: Again filtration is done and particle sizes above 3 micron are separated.

Metering: Metering is the system of measuring the volume of gas.

NETWORK PRESSURE

- HIGH PRESSURE - Steel Pipeline MAOP

  Class 150 #: 19 Kg/Cm^2

  Class 300 #: 49 Kg/Cm^2

- MEDIUM PRESSURE - PE Pipeline

  PE 80 / PE 100

  Pressure Range 4 Bar

- LOW PRESSURE - GI & Copper

  75 Mbar & 21 Mbar

3.1.2 PIPELINES

All the pipelines used for transmitting gas from CGS to DRS, CNG station and other customers are of carbon steel. This steel pipes are used for transmitting gas of higher pressure (19 to 26 bar). Carbon steel pipe can withstand higher pressure.

GI pipes are used for risers in the building and providing connection to the kitchen. Even GI pipes are used in the kitchen pipe fittings. The gas is transmitted by GI pipe at 21 milli bar pressure. Pressure is regulated by pressure regulator at the joint of MDPE and GI pipe. These kinds of pipes are used for low pressure gas.

Copper pipes are used exclusively for kitchen fittings. Copper pipes are used because of its aesthetic view. Copper pipe and GI pipe are almost equal in price.

STANDARD PIPE SIZES BEING USED OD IN MM - 180, 125, 90, 63, 32, 20

ASSOCIATED FITTINGS

- Coupler
- Elbow
- Tee
- Reducer
- Valve
- Transition Fittings
- Tapping Saddles
- End Caps

CATEGORIES OF PE FITTINGS

✓ **ELECTRO FUSION FITTINGS**

Injected moulded polyethylene accessories equipped with a heated element designed to transform electrical energy into heat to create self-welding

✓ **SPIGOT FITTINGS**

PE fittings having smooth ends which require electro fusion accessories to weld to other pipe / fittings

TYPES OF PE FITTINGS

- **PE Pipe Couplers** – It is used for joining pipe to pipe and pipe to fitting
- **Tapping Saddle** – It is used for taking tap-oofs from live lines.
- **PE Shut-Off Valves** – It is used for isolating PE Gas Pipelines.
- **Reducers** – It is used for connecting pipes of different diameters.

- **PE Elbows** – It is used for joining pipes in different angles.
- **Transition Fittings** – It is used as an adaptor for PE to steel / GI.
- **Equal Tee** – It is used for branching of pipeline networks.
- **End Caps** – It is used for installation at the end of pipelines.

MDPE NETWORK

MDPE pipeline is used for PNG distribution. Gas is transported at 4 bar pressure in these lines. After gas is processed and metered in DRS, gas is distributed to domestic house hold through MDPE line. MDPE pipes are strictly used for underground laying. MDPE pipes are goes straight upto the domestic building foundation and for riser GI pipes are used. There are different diameter MDPE pipes are used, like 180mm, 125mm, 63mm, 32mm and 20mm. these pipes are used for underground laying because of its non corrosive properties, it is variables in long length, it is flexible and it has more life.

3.1.3 REGULATING STATIONS

DISTRICT REGULATING STATION (DRS)

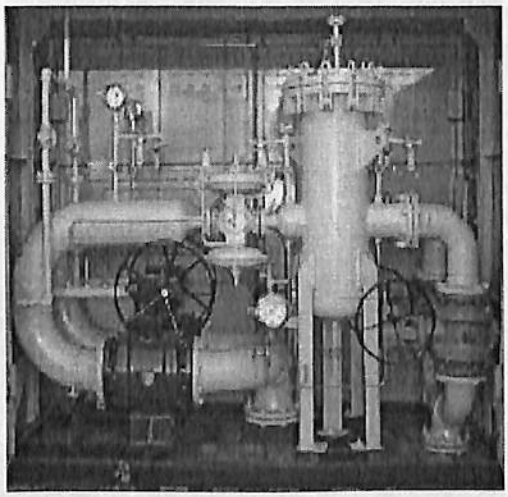


Fig 3.3 District Regulating Station

DRS is a station where gas is collected from CGS through steel grid. In this station filtering, gauging, and metering are done. First gas enters to filter machine and filtration is done. Then pressure is measured by pressure gauge which is around 20 bar. Then gas is passed through turbine meter to measure the amount of gas passed. The pressure of the gas is reduced to 4 bar. Then gas goes for PNG distribution. DRS is used for PNG distribution.

FIELD REGULATING STATION (FRS)

Another form of DRS is FRS. Only difference between DRS and FRS is FRS is having higher capacity. For example DRS uses 500 SCMH and FRS uses 10000 SCMH for processing. FRS has the following features:

- ✓ Type - Twin stream active - Monitor Regulators with slamshut of valves and meter.
- ✓ INLET PRESSURE – 17 to 32 BAR
- ✓ OUT LET PRESSURE – 4 BAR
- ✓ DESIGN PRESSURE- 49 BAR
- ✓ MAX. FLOW- 5000 / 10000 SCMH

SAFETY FEATURES OF FRS

- ✓ ACTIVE - MONITOR REGULATION
- ✓ OVER PRESSURE SHUT- OFF
- ✓ UNDER PRESSURE SHUT-OFF
- ✓ PRESSURE RELIEF VALVE

METERING REGULATING STATION

Metering Regulating Stations are installed at Commercials. They have the following features:

- ✓ Customized
- ✓ Type - Twin / Single stream regulators with slamshut of valves and meter

- ✓ INLET PRESSURE – 19 / 4 BAR
- ✓ OUT LET PRESSURE – AS REQUIRED
- ✓ DESIGN PRESSURE - AS REQUIRED
- ✓ MAX. FLOW - AS REQUIRED

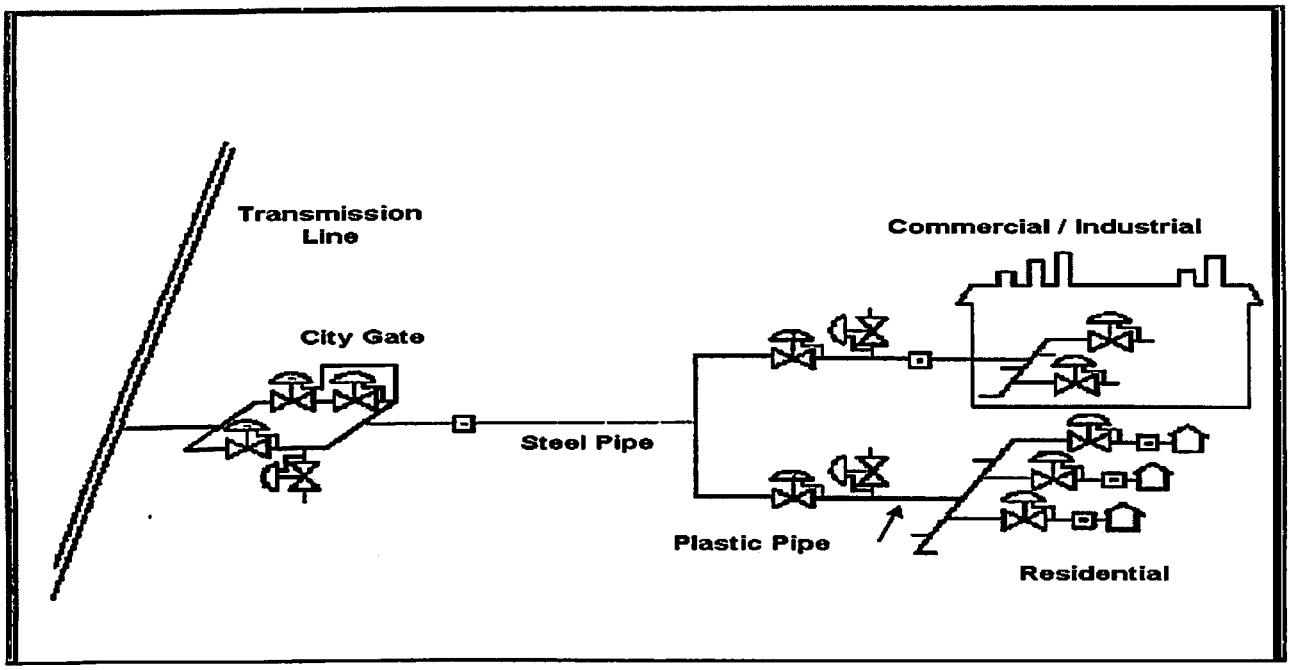


Fig 3.4 Natural Gas Transmission and Distribution

3.1.4 CNG STATIONS

MOTHER STATION

Mother CNG station is the station where all kinds of vehicles are filled with CNG. Here LCV's are also filled with CNG, which carry cascades of CNG to daughter stations. In contrast to PNG, CNG is a high pressure gas required for fuelling vehicles. So gas after traveling through steel grid comes to compressor station. In mother station high capacity compressor is used. Mother station is also known as online station, as gas is directly obtained from HVJ pipeline. First, gas is metered to know the amount of gas flow. Then through suction pipe gas enters into compressor and compressed into three stages.

First Stage- Gas compressed from 18 to 50 bars.

Second Stage- Gas compressed from 50 to 120 bars.

Third Stage- Gas compressed from 120 to 250 bars.

The compressed gas is send to dispensers and vehicles are filled by gas at 200 bars. Pressure can be adjusted in dispensers also. Now cascades loaded LCV's are also filled according to the requirement. The LCVs are used for providing gas to Daughter stations. Mother station is also having its own cascades which are kept for emergency. Buses are given highest priority for filling gas in CNG station, as it is public transporter.

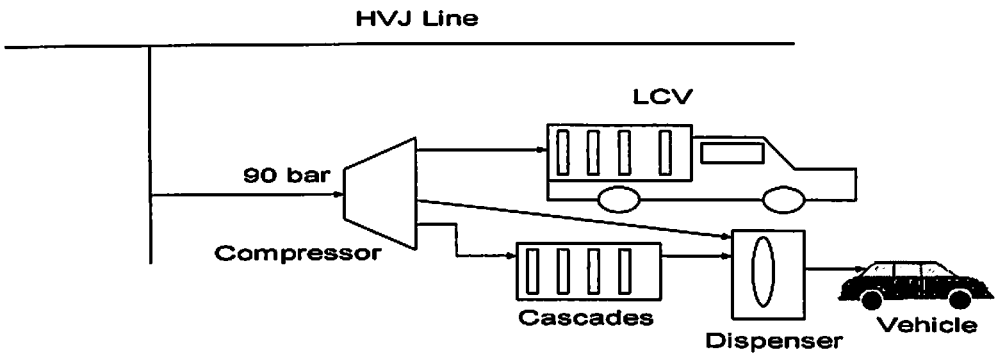


Fig 3.5 CNG Mother Station

DAUGHTER STATION OR DAUGHTER BOOSTER STATION

Areas which are far from main gas line are served by gas through cascades. These cascades are brought to the daughter station by LCVs which are filled in mother station. Cascades are filled by gas at 250 bar pressure but pressure drops below 200 bars due to non usage of gas for time being. So, pressure has to be boosted up to 200 bars for filling the vehicle. So, gas coming from cascades is boosted by a booster to 200 bar and gas is sent to the dispensers. From dispensers gas is filled in the vehicles. Nowadays no daughter station is used without booster. In this station auto rickshaw, taxi, vans are filled with gas.

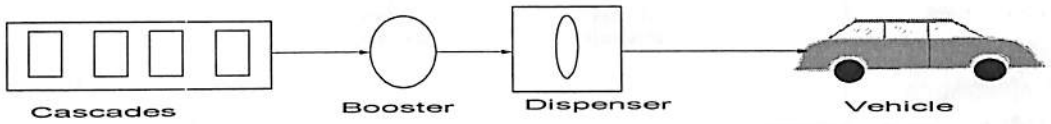


Fig 3.6 Daughter Station

ONLINE STATION

Online CNG station is the station which uses online gases from the main gas line (HVJ pipeline) to fill the vehicle. Only difference between online station and the mother station is, online station uses smaller compressor and it does not have any LCVs. In this station auto rickshaw, van, RTVs are filled with gases.

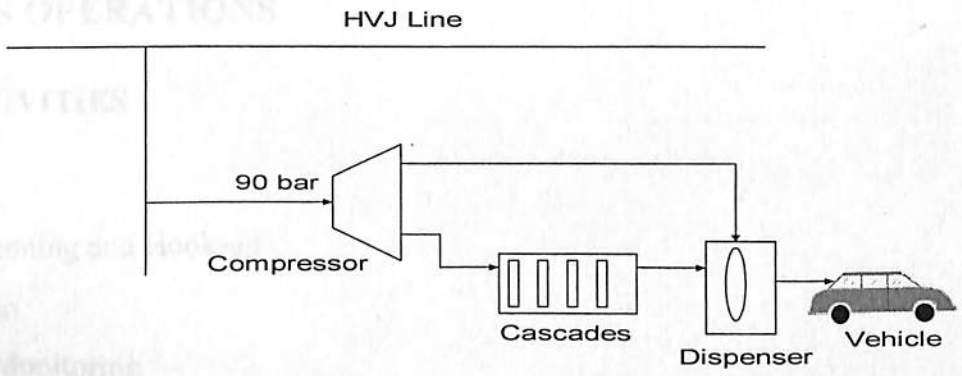


Fig 3.7 Online Station

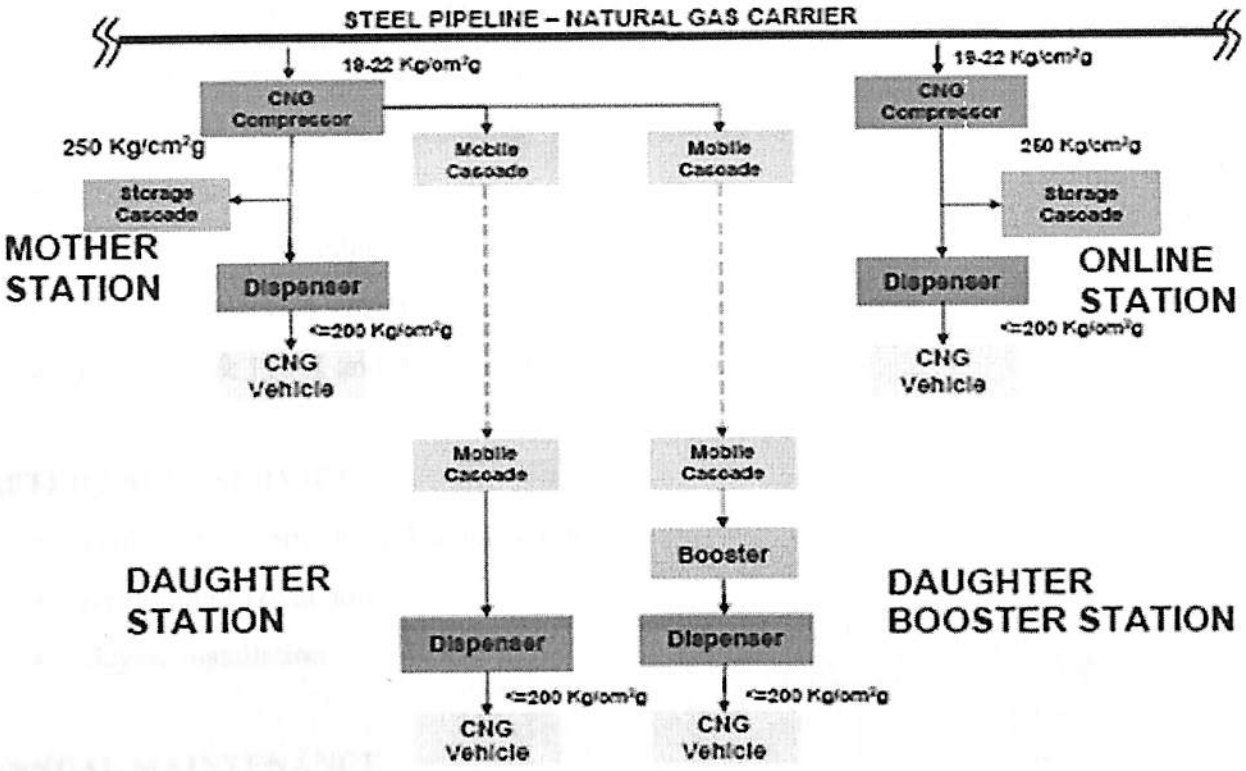


Fig 3.8 CNG Supply Chain

3.2 CITY GAS OPERATIONS

ROUTINE ACTIVITIES

- Patrolling
- Commissioning and Hook-up
- Calibration
- Pressure Monitoring
- Industrial & Commercial Meter Reading
- Gas Balancing
- Odourisation
- Cathodic Protection monitoring
- DCVG Survey

MAINTENANCE

- Routine maintenance of MRS, DRS, TR Unit
- Steel / PE Valve Chamber cleaning
- Steel Valve Assembly overhauling
- PE Diversion
- Stop off Valve installation
- FID Gas detection survey
- ISO 9002 & 14001 and Asset Integrity compliance

AFTER SALES SERVICE

- Temporary / Permanent disconnection
- Re routing / Diversion
- Geyser installation

ANNUAL MAINTENANCE

Soundness check on Domestic / commercial installation. It includes,

- Meter – Regulator Installation
- Riser
- Service Regulator

EMERGENCY HANDLING

- Gas Escape: Steel / PE damage
- Gas smell
- High / Low Pressure problem
- Meter damage

3.3 CONTROL SYSTEMS IN CITY GAS DISTRIBUTION

Control Systems are applied in City Gas Distribution networks for automation. The reasons for automation are:

- Effective monitoring of pressure, flow, quality on the P/L network, feeder stations and consumers (bulk / retail).
- Demand forecasting based on consumer consumption pattern tracking and fulfilling demand
- Meeting demands through alternate sources in case of primary source failure
- Consumer timely automated billing and hence faster money realization
- Mapping pipeline network thru GIS for quicker complaint resolution

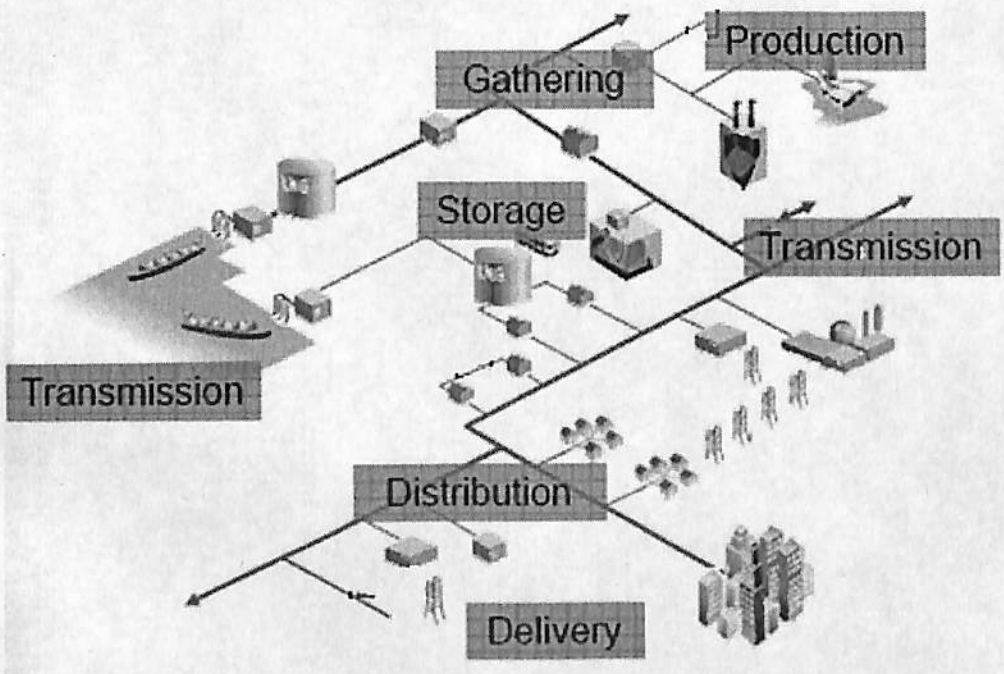


Fig 3.9 The Gas Grid

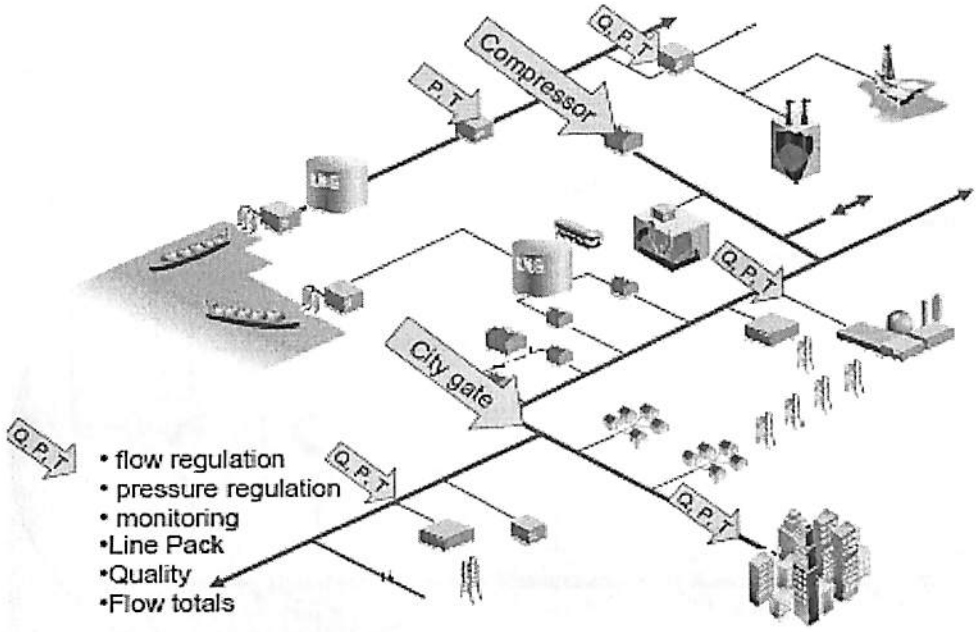


Fig 3.10 The Gas Grid Elements

THE CITY GAS NETWORK BUSINESS MATRIX

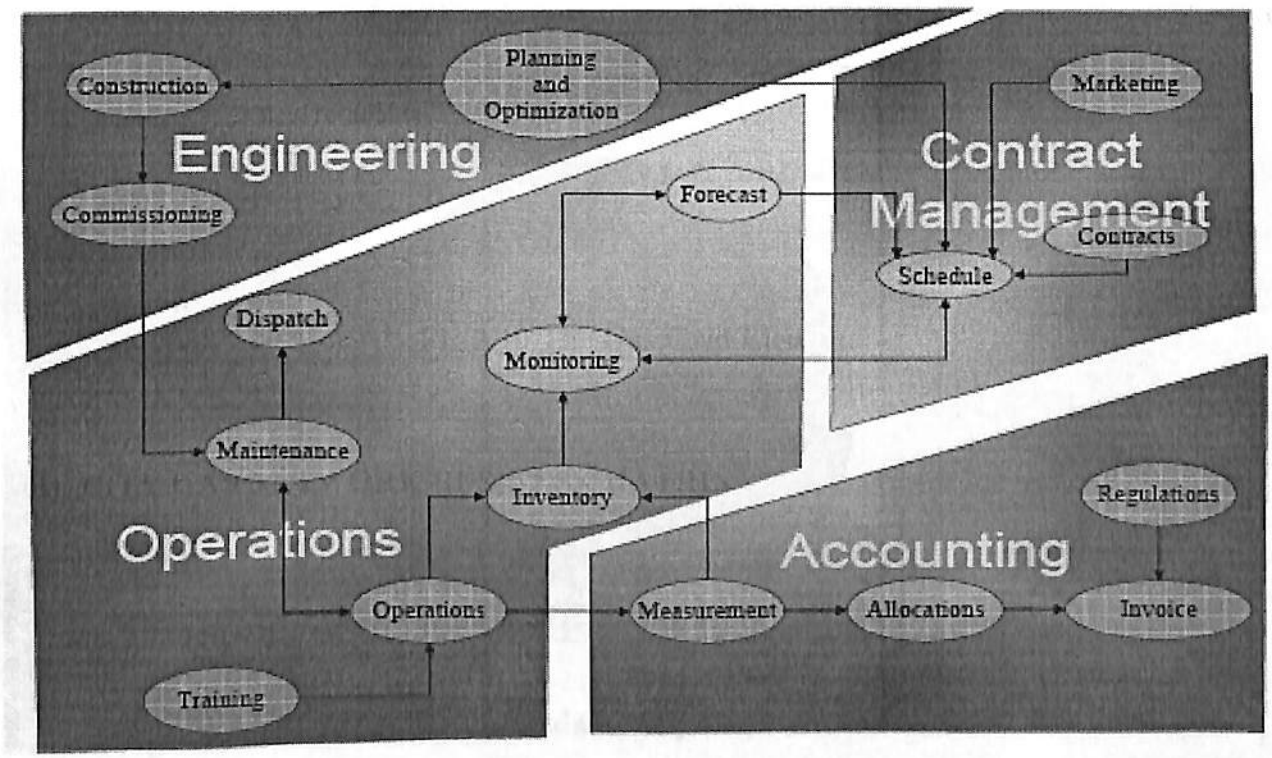


Fig 3.11 City Gas Network Business Matrix

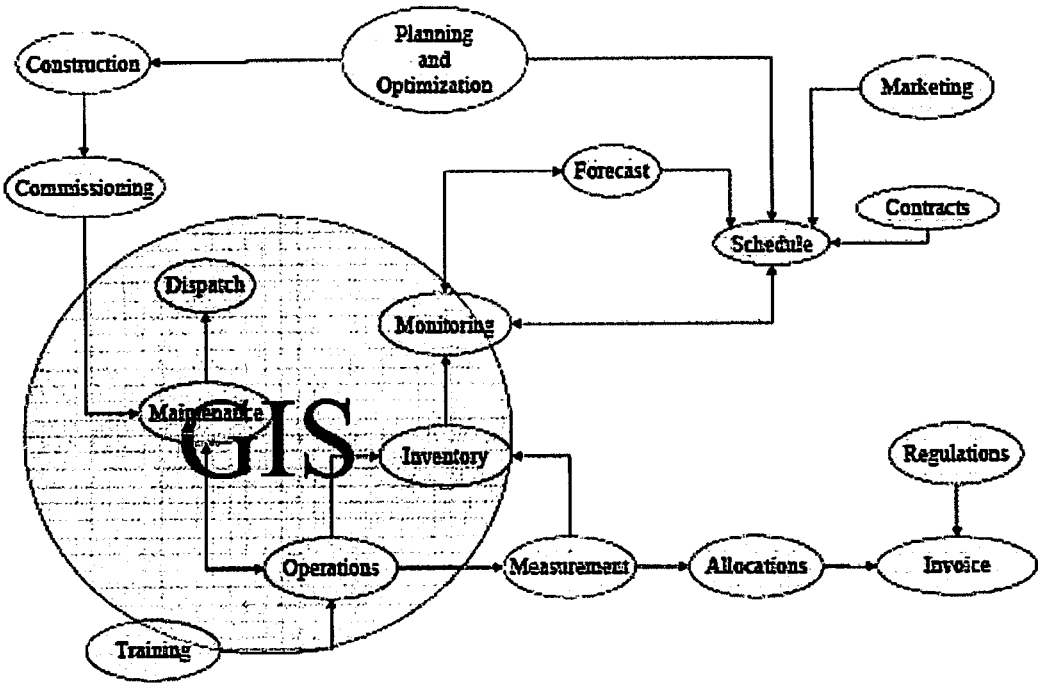


Fig 3.12 Application of GIS in City Gas Network Business Matrix

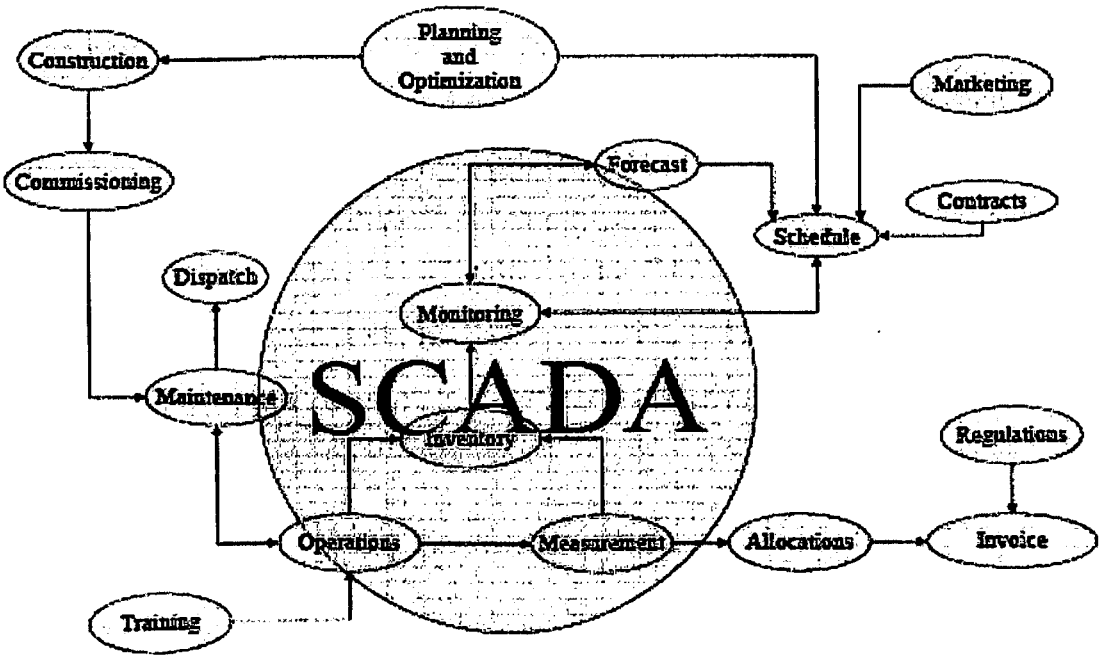


Fig 3.13 Application of Scada in City Gas Network Business Matrix

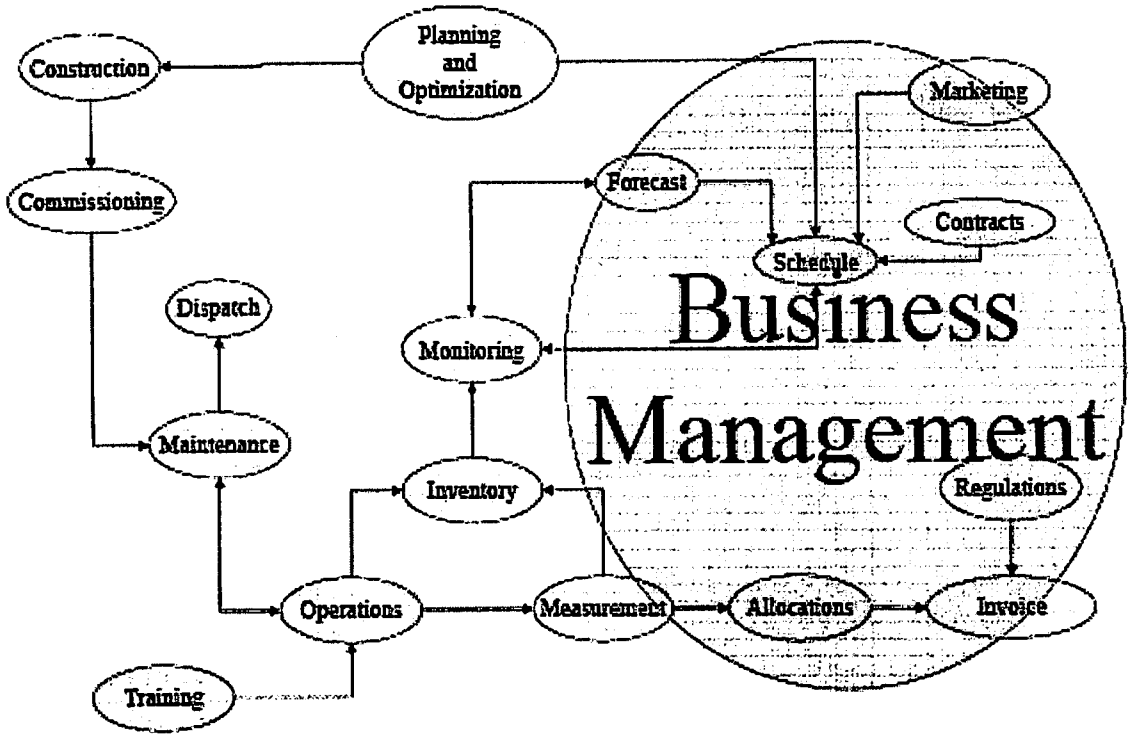


Fig 3.14 Application of Business Management in City Gas Network Business Matrix

FUNCTIONALITY WITH SCADA, RTU AND TELEMETRY LINKS

- Daily Reporting of Purchases from Source
- Online monitoring of all Mother Station (MS) & Daughter Station (DS) parameters.
- Report of Compressed Gas, Odorant stock, Stock Transit in Mobile cascade, turnaround time of Mobile cascade, Dispatch & Receipt, Date-Time Stamp in between MS & DS and CNG Stock at Fixed Cascades at Mother & Daughter Stations.
- Report Sales/ Collections through dispensers at MS & DS
- Calculation of Stock loss, Daily & weekly Forecast, Data Storage
- Consolidated MIS Reporting on daily, weekly, fortnightly & Monthly basis for above
- Billing

3.4 COSTS INVOLVED IN CGD NETWORKS

- Cost involved in CGS is numerous. Including material and execution the total cost involved is around Rs 1.2 crores.
- Costs involved in laying of steel grid using pipelines is as follows:
    - 4" CS Pipe- Rs 35, 00,000 / Km
    - 6" CS Pipe- Rs 55, 00,000 / Km
    - 8" CS Pipe- Rs 75, 00,000 / Km
    - 12" CS Pipe- Rs 1, 00, 00,000 / Km

  (It includes material, execution & statutory charges. Statutory charges are paid to MCD, NDMC and PWD)
- Costs of the MDPE pipes are as follows:
    - 180 mm- Rs. 800/mtr
    - 125 mm – Rs. 400/ mtr
    - 63 mm – Rs 100/ mtr
    - 32 mm – Rs. 40/mtr
    - 20 mm – Rs. 25/ mtr
    - 10-20 % of the costs are taken for fitting.
    - Execution cost for 20 to180 mm pipe is Rs.180 to Rs 320/ meter. If a pipe has to be passed through road or some kind small physical structure then trenching or boring has to be done instead of digging. For these cost involve is Rs. 1100 to Rs 1800/ meter.
- For GI piping, it costs around Rs 250/meter. It includes materials and execution cost also.
- DRS or FRS costs around 30-40 lakhs. It includes material and execution costs too.

3.5 COSTS INVOLVED IN CNG STATIONS

MOTHER STATION

- Cascades of 2400 to 3000 liter cost around 10 to 12 lakhs / each.
- Dispensers costs around 16 to 18 lakhs.
- Compressors are available in different capacities like 250, 400, 600, 1200 SCMH. They costs around 0.75 to 1.5 crore.
- Mother Station's overall cost is around 4.5 crore. (Mother station includes building, compressor, dispensers, cascade, electrical connections, Air compressor, DG set, tubing, fitting).

S.No.	Component	Cost (Rs.in Mn.)
1	Compressor	20.00
2	Cascade (2 Nos. 200 Liter)	4.00
3	1 Dispenser	3.00
4	2 Power Dispenser	3.00
5	Civil & Other misc. works	7.50
6	Piping & Instrumentation	0.25
7	Fire detection	0.15
8	DG Set	1.00
9	Contingency	0.70
	Total	**39.60**

Table 3.1 Costs involved in CNG Mother Station

On-Line Station

S.No.	Component	Cost (Rs.in Mn.)
1	Compressor	7.50
2	1 Cascade	2.00
3	2 Cascade Dispenser	3.00
4	Civil & Other misc. works	7.50
5	Piping & Instrumentation	0.25
6	Fire detection	0.15
7	DG Set	1.00
8	Contingency	0.70
	Total	**22.10**

Table 3.2 Costs involved in CNG Online Station

Daughter Station

S.No.	Component	Cost (Rs.in Mn.)
1	1 Dispenser	1.50
2	2 Mobile Cascade	3.00
3	Civil & Other misc. works	7.50
4	Contingency	0.70
	Total	**12.70**

Table 3.3 Costs involved in CNG Daughter Station

Daughter Booster Station

S.No.	Component	Cost (Rs.in Mn.)
1	2 Compressor	3.00
2	1 Cascade	0.15
3	2 Mobile Cascade	4.50
4	Civil & Other misc. works	7.50
5	Contingency	0.70
	Total	**15.85**

Table 3.4 Costs involved in CNG Daughter Booster Station

3.6 COSTS INVOLVED PER HOUSE

- **Flats / Society** - Costs involved per house in flats / society is Rs. 12000. This cost starts from 32mm and 20mm MDPE pipe and GI pipe up to kitchen.
- **Single House** - Costs involved in single house or bungalow is Rs 25,000 per house. This cost starts from 32mm and 20mm MDPE pipe and GI pipe up to kitchen.
- **Small Commercial** - Costs involved is Rs 75,000 to Rs 1,00,000. This cost starts from 32mm and 20mm MDPE pipe and GI pipe up to kitchen.
- **Large Commercial** - Cost involved is Rs. 8 lakhs. Works till MRS (Meter Regulating System) costs these price and rest of the work done by the company.

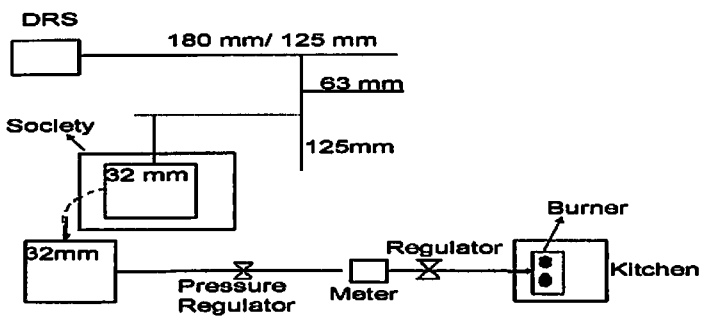


Fig 3.15 Pipeline Network for Domestic Building

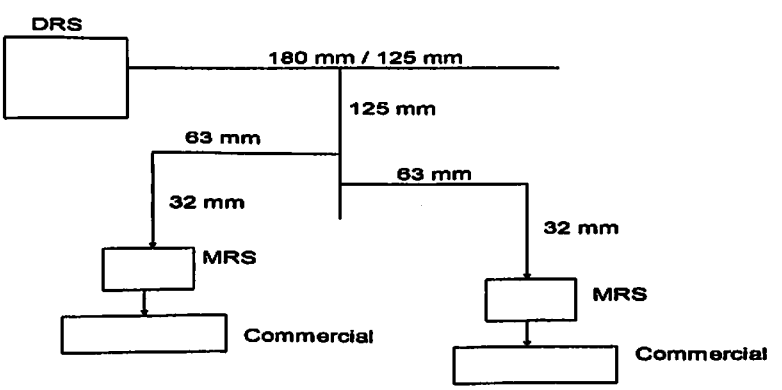


Fig 3.16 Gas Pipeline Network for commercial Setup

3.7 KEY PARAMETERS FOR FINANCING OF CGD PROJECTS

The parameters to be taken into consideration for financing of a CGD project are:

- Population of the city where the CGD project is going to be implemented should be considered. Then the target population should roughly be estimated.
- The demand segments for the project should be considered namely:
    - Household
    - Transportation
    - Industrial
- Capital Expenditure required for the project should be estimated.
- Exclusivity for City Gas Distribution should be considered.

DEMAND – DOMESTIC AND COMMERCIAL

- Domestic demand is based on the total number of households in the city under consideration.
- Adjustments for slums / outskirt houses undertaken for number of potential connections.
- Commercial Demand is generally assumed to be 10% of the domestic demand numbers. However this assumption would vary according to the city under consideration.

DEMAND – TRANSPORTATION

- Higher Penetration rate for public transportation – Supreme Court Directives, State Government Initiatives
- Other vehicles will convert based on price competitiveness and ease of availability.

INDUSTRIAL DEMAND

- Industrial demand constitutes a major portion of the total demand for any CGD project.
- Switching is primarily driven by price competitiveness.
- Other factors include supply stability, environmental aspects etc.
- Penetration rates of solid fuels have been taken to be lower due to low price affordability.

TOTAL DEMAND

- Approximately 70% of the total demand is from the industrial sector, followed by CNG at 15 %; Commercial and PNG contribute to the remaining 15%.
- Demand from the domestic segment is expected to grow as the pipeline infrastructure comes up.
- Transportation segment demand also expected to have higher growth rates.

CAPEX PROJECTIONS

- Capital Expenditure is projected based on the expenditure for laying of pipelines and development of CNG stations.

PRICING ASSUMPTIONS

- Gas purchase price and gas sales price assumptions are assumed.
- Transportation tariff of the pipeline is also considered.

EQUITY IRR ANALYSIS

- Equity IRR of the city gas project is based on assumptions like:
    - CGD Developer is a Gas transporter.
    - CGD Developer is both a gas transporter and marketer.
- Debt Equity ratios vary between 100% equity to 30% equity.

RETURNS TO INVESTORS

- City Gas projects offer attractive Debt Coverage and Cash flow ratios for project lenders.
- Equity IRRs are attractive – for strategic and PE investors.
- Strategic investors may include gas suppliers, equipment suppliers, infrastructure companies, state and local governments.
- Further upsides can come from additional demand centers, higher penetration rates, appropriate project structuring and efficiency in operations.

3.8 FINANCIAL STRUCTURE OF CITY GAS PROJECTS

Financial Structure is influenced by:

- Project Cost Structure
- Implementation philosophy
    - Master Planning vs. Project basis
- Ownership
    - Private vs. Public
- Focus Area
    - CNG, PNG

Project Cost Structure can be represented in various ways

- Finance Structure Options -
    - Debt : Equity Ratio
    - Customer Contribution (meter, spur lines,deposits etc) as Quasi Equity
    - Internal Accruals

Implementation Philosophy

Stress On	Implementation	Development Philosophy	Funding	Example
CNG	Master Plan Based	Infrastructure First	Large Debt and Equity Infusion	Indraprastha Gas
PNG(DOM)	Phased Development	Development in Sync with Demand	Domestic Customer Contribution	Mahanagar gas
PNG (IND)	Phased Development	Development follows the market	Phase Wise ("Project Wise"). Mostly through internal accruals	Gujarat Gas

Table 3.5 Implementation philosophy with examples

3.9 ECONOMICS OF CNG

Some facts about CNG

1 Kg CNG gives 1.6 times more mileage than 1 Liter of Gasoline.

1 Kg CNG contains as much energy as 1.39 Liter of Gasoline.

Energy Economics of CNG

We will take an example of Maruti 800 car for analyzing energy economics of CNG. On an average Maruti800 gives 15 km/ lit mileage using petrol and (15x1.6) 24 km/kg mileage using CNG. So, amount of energy content in 1 Kg of CNG gives 24 Km mileage. With same amount of energy from gasoline, it will give (15x1.39) 21 Km mileage. So, we can see that even using same amount of energy CNG gives better mileage then gasoline. This is because of higher ignition temperature of CNG then gasoline. Using CNG is not only saving your cash but also it is saving energy for the country.

COST ECONOMICS OF CNG

Taking the same example of Maruti800, which gives mileage of 15 Km/lit using Gasoline and gives 24 Km/kg using CNG.

Price:

Gasoline: Rs 43.5/ lit

CNG: Rs 19.20 /Kg

Expenses per Km:

Gasoline: Rs 43.5/15 = Rs 2.9

CNG: Rs 19.20/24 = Rs 0.80

Expenses per day

(Suppose a car travels an average of 100 km per day)

Per day expenses using Gasoline is Rs 2.9 x 100Km = Rs 290

Per day expenses using CNG is Rs 0.80 x 100Km = Rs 80

So, there is a saving of (Rs 290- Rs 80) Rs 210/day.

CNG Kit cost is Rs 35,000s

Payback period is Rs 35,000/Rs210= 167 days or 5 months 17 days.

So, after 167 days Rs 210 is a profit per day using CNG. That means (Rs 210 x 30) Rs 6300 per month can be saved using CNG.

Analysis of earning of an auto rickshaw per month using CNG:

Mileage: 35Km /Kg

Cost: Rs 19.20 / Kg

Cost per Km: Rs19.20/ 35 Km= Rs 0.55

Auto Fare: Rs 4.5 .Km + Rs 10 down payment

Average distance traveled per day: 100 Km

Fuel cost per day: 0.55 x 100= Rs 55

(Suppose 15 % is the idle movement and makes 10 trips a day)

Gross earning per day: Rs 4.5 x 85 Km +Rs10 x10 = Rs 482.5

Other costs are

Maintenance cost: Rs 400/ Month

Road tax: Rs 305 / yr

Pollution under control (PUC): Rs 35 / quarterly

Insurance: Rs 1600 / yr

Depreciation: 10%

Auto Rickshaw cost: Rs 3, 60,000 @ 10 % interest

Calculation of the profit:

1. Gross Profit per month: Rs 482.5 x 30 = Rs 14,475
2. Fuel cost per month: Rs 55 x 30 = Rs 1,650
3. Maintenance cost per month: Rs 400
4. Road tax per month: Rs 305 / 12 = Rs 25
5. PUC per month: Rs 35 / 4 = Rs 12
6. Insurance per month: Rs 1600 / 12 = Rs 133
7. Depreciation per month: @ 10% of 3.6 lakhs = 36,000 / 12 = Rs 3,000

Net Earnings per month = Rs 9255

This earning is subject to change with different Auto Rickshaws. This earning calculation is done by surveying 20 Auto Rickshaw drivers in Delhi.

CNG CONVERSION ECONOMICS

The following table shows the economics of vehicle conversion to CNG by using the CNG conversion kit:

Particulars	Auto	Taxi	Private Cars
Conversion Kit Cost - CNG	22,000	32,000	32,000
Daily Running Km	80	80	50
Average on Petrol/Diesel	25	17	17
Average on CNG per SCM	30	20	20
Cost (Rs.)			
Petrol (per litre)	37	37	37
CNG (per SCM)	15	15	15
Average Benefit per Km - CNG	0.98	1.43	1.43
Benefit on CNG per day	78.40	114.12	71.32
Payback Period in Months - CNG	9.35	9.35	14.96

Table 3.6 CNG Conversion Economics

	Prices					
Fuel	Unit	Rs/Unit	Kcal	BTU	Rs/ MMBTU	$/ MMBTU
Petrol	Litre	49	12070	47894	1023	23.3
Diesel	Litre	37	10200	40474	914	20.8
LPG	Kg	25.2	10450	41466	606	13.8
CNG	Kg	20.9	10000	39680	527	12.0

Source : CRIS Infac

Table 3.7 Comparison of CNG prices with other fuels

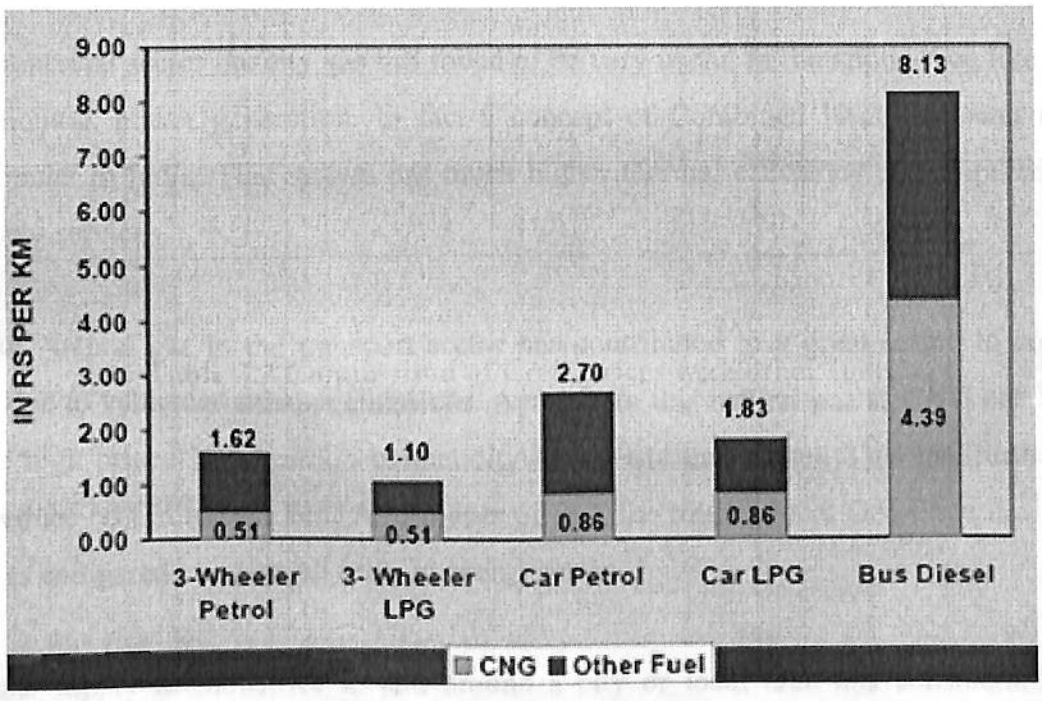


Fig 3.17 Comparison of CNG with other fuels in Rs per KM

CHAPTER 4: CITY GAS DISTRIBUTION SCENARIO IN INDIA

The most benign use of Natural Gas is in City Gas Application. This sector comprises of:

i. Domestic household use
ii. Commercial use in hotels, hospitals, restaurant and offices
iii. Transport sector use in Three wheelers, buses, trucks and cars
iv. Industrial Sector use in the Small Scale Industry including Power generation.

The Household use of gas has picked up in India especially when multiple use of Natural Gas in the houses was demonstrated. The gas can be used for cooking, water heating, space heating, air conditioning, refrigeration, power generation and fuelling the vehicle. The concept of a single switch solution in the household sector is picking up momentum. This concept provides that a household could be self contained gas users to meet its all energy needs at one go that means once the gas supply is switched on, all these services can be secured which are all gas based of course selectively or need based.

In the commercial sector the city gas has found to be very useful in the application like cooking, air conditioning, power generation. In fact a concept of Combined Heat & Power (CHP) is getting popular in India. This system has much higher thermal efficiency as compared to other conventional services.

The use of Natural gas in the transport sector has contributed to a great extent to contain the pollution due to vehicular exhaust emissions. Apart from this natural gas as CNG has been able to replace high priced hydrocarbon commodity like petrol and diesel. This has further helped India to reduce its Oil Import Bill. As a matter of fact, the international Gas Price is always 10-15% less as compared to crude oil price in energy terms.

Natural gas supply to industries in and around a city or local area has considerably helped reducing pollution in the cities apart from providing ease of operation and fuel handling to the industries.

4.1 INDIAN HISTORY OF CGD

PRE INDEPENDENCE (<1947)

City Gas distribution had taken place in Calcutta (now Kolkata) before Independence (1947). Since there was no Natural Gas, Synthesis Gas was made available for the domestic use. Synthesis Gas is formed by partial burning of coal. One of the gasification locations was in Dhankuni. Even in Bombay concept of gas came before independence. Jalan Industries developed Bombay City Gas.

Driver for using City Gas

British invaded India in eighteenth century. They used woods as fuel for cooking and heating purpose. They were intelligent to find an alternate source of fuel. They never wanted an Indian to enter their home and also wanted to handle the fuel themselves with ease. These are the reasons why they started using synthesis gas.

Retarders

We will look at the process of making synthesis gas, from where we can come to a position to decide upon the retarders of city gas use at that time.

$$C + O2 + H2O \longrightarrow CO + H2$$

Coal contains carbon and moisture. When coal is burned by partial oxidation method in presence of moisture then it gives carbon monoxide and hydrogen.

$$2CO + O2 \longrightarrow 2CO2 + Heat$$

$$2H2 + O2 \longrightarrow 2H2O + Heat$$

Then carbon monoxide is oxidized and gives out carbon dioxide and heat. On the other hand hydrogen gets oxidized and gives out waste (water) and heat.

So, it is clear from the reactions that, synthesis gas gives out carbon monoxide which is poisonous and environmentally unexpected. Other reasons were as follows.

1. High cost of production

2. Gas was available at very low pressure for cooking

3. Transportation cost was high

4. There was a storage problem due to the generation of carbon monoxide during the production of synthesis gas.

5. Gas was not enough for mass use

6. Technology was a barrier as it was very old

POST INDEPENDENCE (1947-1977)

First oil was struck in Makum, Assam in 1867 but first commercial oil was discovered in Digboi, Assam in 1889. Gas was present at that time too. So, obviously gas was present in post Independence time too. But people didn't know the technology to extract it. People saw fire from gas seepage. People used to tap gas into tier or directly cooked food keeping the cooking utensils on the seepage. Technology and ignorance were the main barriers at that time for non usage of gas.

NEW INCARNATION (1977-2000)

With discovery of Bombay High India saw a new era of gas market. Gas has been started to be used as commercial fuel and domestic fuel. But India didn't see much of growth because nobody was willing to substitute their alternate fuels. People were ignorant about gas. They thought that if gas enters home it can cause accident. They didn't know the technology. Gas was costlier then alternate fuels. Availability of gas was not enough. These are the few reasons why gas didn't see so much of growth at that time.

NEW ERA (2000-2007)

Gas consumption has increased tremendously in this period and this was driven by Environmentalist. PIL (Public Interest Litigation) in Supreme Court was the prime reason for gas evolution in large scale. Due to Supreme Court order, mega city Delhi's transportation system saw huge turnaround. All public vehicles were converted to CNG fleet. Then Mumbai applied the same formula. Other cities are lined up for the change. This change would require gas in huge amount. Over the period of time people became more knowledgeable about technology and process. People started using gas with ease. People started to realize that gas is much better than

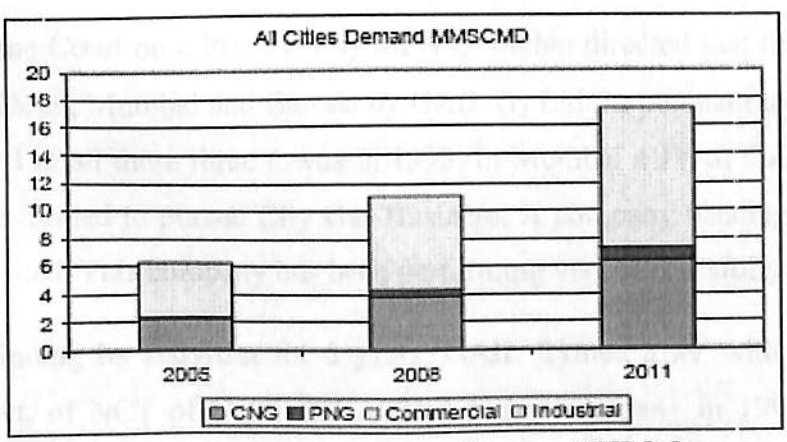
other domestic fuels. Gas is available round the clock. Gas storing is not required. Every month you need not need to buy gas like LPG. Billing system is very user friendly. Most importantly price of gas is matched with subsidized LPG and became affordable too.

4.2 POTENTIAL OF CITY GAS NETWORKS IN INDIA

Natural Gas usage in Indian cities has been limited primarily due to the scarcity of supply. However this scenario is undergoing change with several LNG projects/transnational pipelines under implementation, which together with new domestic Gas finds are expected to shore up the supply deficit in the next few years. Meanwhile the market for city gas distribution is also set to grow at an accelerated pace. The CNG demand got a boost with the Supreme Court directive on pollution reduction in 12 major cities in India. The domestic segment is also expected to grow with the government's intentions to remove the subsidy on LPG cylinders in a phased manner in 3-5 years making piped gas even more economical.

PRE-REQUISITES TO REALISE THE POTENTIAL

- Availability of natural gas
- Regulatory push
- Existence of trunk pipeline which will be driven by anchor customers
- Suitable incentives for development of distribution networks in defined geographical areas



Source : CRIS Infac

4.1 Likely Potential from identified cities

Cities identified for development of distribution business

- North –15 cities
- East –2 cities
- West –12 cities
- South –8 cities

4.3 DEVELOPMENT OF CITY GAS IN INDIA

In the early stage, the city gas was only started on experimental basis, primarily to utilize the locally produced gas. Such locations had been Duliajan, Moran, Nazira, Sibsagar in Assam, and Baroda in Gujarat. The structured use of Natural Gas in domestic sector in Assam, started after formation of Assam Gas Company in 1962. In addition, the metros of Mumbai and Kolkata used Coal Gas for City Gas Usage way back since pre-independence. The coal gas which is also known as Synthesis Gas did not find a commercial business model and abandoned in Mumbai way back in 1981. In Kolkata this concept is still working after the original company the Oriental Gas was succeeded by Greater Calcutta Gas Supply Corporation in 1987, however it is on the retardation phase.

The development of City Gas in India remained localized for quite long time. It was only in 80's when structured development of City Gas took place in India. The Gujarat Gas Company is the example of this initiative when Govt. of India allocated gas for development of City Gas in Ankleshwar and Bharuch.

In early 90's Supreme Court on a PIL filed by Sh N.C. Mehta directed that the City Gas should be implemented in Delhi, Mumbai and Baroda by GAIL (I) Ltd. In pursuant to this direction, the CNG was introduced in all these three towns in 1993. In Mumbai a JV of GAIL, BG and Govt. of Maharashtra was formed to pursue City Gas Business. A company was registered in 1995 as Mahanagar Gas Limited. This company has been performing very successfully since then.

In Delhi after continuing its activities for 5 years, GAIL formed a JV with Bharat Petroleum Corp. Ltd. and Govt. of NCT of Delhi and created a new company in 1998 by the name of Indraprastha Gas Limited. Refer to Appendix 2 for development of CGD in India from 2002-05.

Subsequently, there have been various initiatives in the City Gas Distribution (CGD) Projects. As of now, the numbers of companies operating in CGD are as under:

1. Assam Gas Company Ltd, Duliajan, Assam
2. Tripura Natural Gas Company Ltd, Agartala, Tripura
3. Gujarat Gas Company Ltd (GGCL), Surat, Gujarat
4. Baroda Municipal Corporation Ltd, Baroda, Gujarat
5. Charotar Gas Sehkari Mandali Limited
6. Great Eastern Energy Corporation Ltd.
7. Mahanagar Gas Ltd (MGL), Mumbai, Maharashtra
8. Maharashtra Natural Gas Company Ltd, Pune, Maharashtra
9. Indraprastha Gas Ltd (IGL), Delhi
10. Bhagyanagar Gas Ltd, Hyderabad, AP
11. Green Gas Ltd, Lucknow, UP
12. Central UP Gas Ltd, Kanpur, UP
13. Avantika Gas Ltd. MP
14. Gujarat State Petroleum Corporation Ltd, Ahmedabad, Gujarat
15. Adani Energy Ltd, Ahmedabad, Gujarat
16. Sabarmati Gas Ltd, Gandhinagar, Gujarat
17. Kolkata City Gas Co. Kolkata WB
18. Haryana City Gas Limited, Gurgaon, Haryana*
19. Sity Energy Limited, Delhi*
20. Reliance Industries Ltd*
21. Reliance Energy Ltd*
22. Krishna Godavari Gas Ltd (JV of GSPCL & Govt of AP)*

*- Operation yet to start

Year	City	Company
~ 1880	Calcutta	Calcutta Gas Company
~ 1900	Mumbai	Bombay Gas Company
1972	Vadodara	Vadodara Municipal Corporation
1980	Delhi	Delhi Municipal Corporation
1982 ~ 1986	ONGC Colony at Mehsana & Sibsagar	ONGC
1985	Duliajan	Assam Gas Company
1986	Sibsagar	Assam Gas Company
1989 ~91	Surat, Ankleshwar, Bharuch	Gujarat Gas Company Ltd
1994	Mumbai	Mahanagar Gas Ltd
1995	Delhi	Indraprasthta Gas Ltd
2004	Vadodara & Ahmedabad	Adani Energy Limited
2005	Hyderabad	Bhagyanagar Gas Limited
2006 ~2007	Gandhinagar, Kadi, Mehsana, Rajkot, Morbi, Vapi	GSPC Gas / Sabarmati Gas
2006	Kanpur, Lucknow	CUGL & GGL

Table 4.1 HISTORY OF CGD IN INDIA

CGD IN INDIA – UP TO NOW

- Limited to few towns and cities located near existing gas sources/transportation networks.
- Underdevelopment due to constraint in gas availability and absence of transmission infrastructure.
- Lack of clear regulatory and fiscal framework
- Current CGDs account for less than 15% of domestic consumption
- Predominantly Transportation and industrial users

CGD IN INDIA – CHANGING SCENARIO

- Huge domestic gas discoveries.
- Huge Investments in a Pan India Network creating a gas grid providing connectivity to over 300 cities and towns to reach nearly 20 million households.
- Focused approach on setting up regulatory framework with PNGRB in place.
- Should also aim at deeper penetration to semi urban / rural India.
- Emerging technologies to catalyze efficient usages for a total energy solutions and eco friendly life style.

4.3.1 OWNERSHIP PATTERN OF CGDs IN INDIA

Company	Place	Ownership
Calcutta Gas Company	Calcutta	Private
Bombay Gas Company	Mumbai	Private
Vadodara Municipal Corporation	Vadodara	Local Govt.
Delhi Municipal Corporation	Delhi	Local Govt.
ONGC	Mehsana, Kadi, Hazira, Sibsagar	ONGC
Assam Gas Company	Duliajan, Sibsagar	Govt. of Assam
Mahanagar Gas Limited	Mumbai	GAIL, BG, Govt. of Maharashtra
Indraprastha Gas Limited	Delhi	GAIL, BPCL, Govt. of Delhi, ILFS, IDFC
Gujarat Gas Company Limited	Surat, Ankleshwar, Bharuch	Mafatlals, GIIC (now owned by BG)
Adani Energy Limited	**Ahmedabad, Vadodara**	**ADANI GROUP - 100% private**

Table 4.2 Ownership Pattern of CGDs

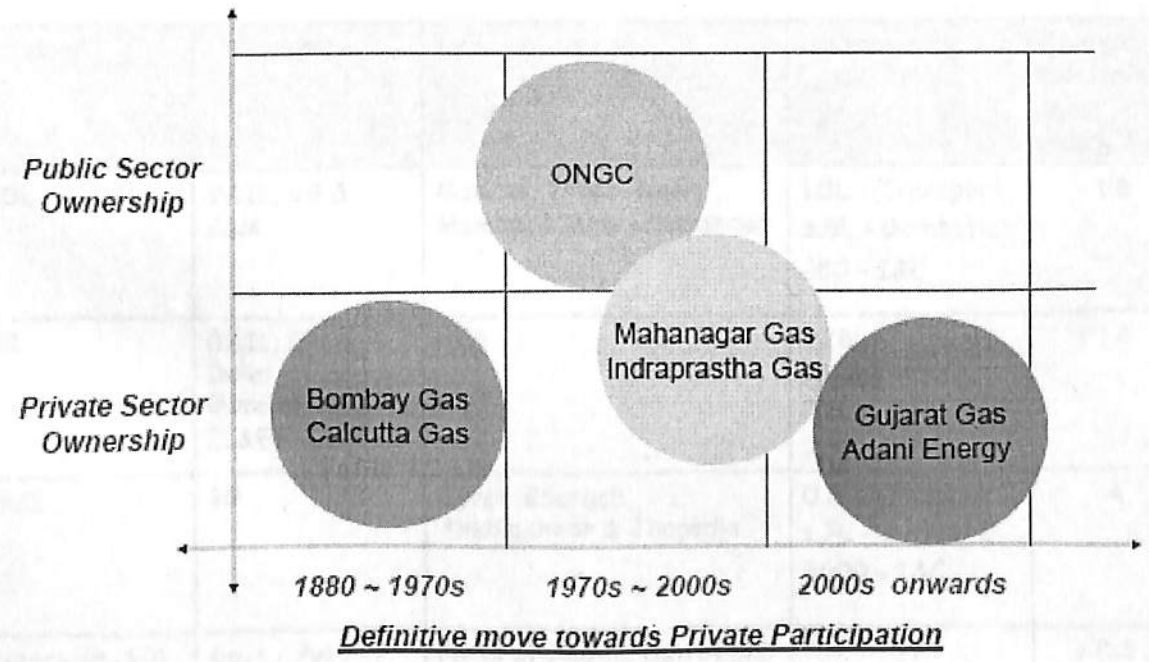


Fig 4.2 Changing Ownership Pattern

4.3.2 CITY GAS PROJECTS IN INDIA

- There are 20 cities in which city gas distribution networks have been implemented.
- The total distance is 11,000 Km of distribution networks.
- There are a total of 380 CNG stations in India.
- The throughput of gas is 8.5mmscmd.
- There are a total of 5.5 Lac Gas customers.
- There are a total of 4.6 Lac CNG vehicles running in India.

4.3.3 CITY GAS PLAYERS IN INDIA

- NOCs
- Private Companies
- State Govt. companies
- JVs of above

SOME EXISTING MARKET PLAYERS IN CGD BUSINESS

Company	Ownership	Existing Areas	Customer base	Approx Gas sales in MMSCMD
MGL	GAIL, BG & GoM	Mumbai, Thane, Navi Mumbai & Mira -Bhayander	1.8L - Transport 3.6L - Domestic 850 - I&C	1.5
IGL	GAIL, BPCL, Delhi Government, IL&FS, IDFC	NCR	1.2BL - Transport 0.8L - Domestic 260 - I&C	1.6
GGCL	BG	Surat, Bharuch, Ankhleshwar & Jhagadia	0.3L - Transport 1.7L - Domestic 3000 - I&C	4
Others (8-10)	Govt / Pvt / JVs	Parts of Assam, Gujrat and AP	??	> 0.6 ?

Table 4.3 Existing Market Players in CGD Business

EMERGING PLAYERS

- GAIL
  - Through JVs with existing National Oil Companies
- Reliance
  - Along its East-West transmission pipeline
- Adani Energy
  - Currently developing networks in 6 cities
- British Gas
  - New Initiatives in Southern India
- GSPC Gas
  - All major cities of Gujarat (except Ahmedabad & Vadodara)

EXISTING JOINT VENTURES COMPANIES

S.No	JVC	AREA OF OPERATIONS	JV PARTNER
1	MAHANAGAR GAS LIMITED	Mumbai, Mira- Bhayendar, Navi-Mumbai, Thane	BRITISH GAS
2	INDRAPRASTHA GAS LIMITED	Delhi & NCR	BPCL
3	BHAGYANAGAR GAS LIMITED	Andhra Pradesh	HPCL
4	TRIPURA NATURAL GAS COMPANY LIMITED	Tripura	AGCL & TIDC
5	CENTRAL U.P GAS LIMITED	Kanpur, Bareilly and cities of Eastern U.P	BPCL
6	GREEN GAS LIMITED	Lucknow, Agra, Cities of Western U.P & Uttaranchal	IOCL
7	MAHARASHTRA NATURAL GAS LIMITED	Maharashtra except Mumbai, Thane and Navi Mumbai	BPCL
8	AAVINTIKA GAS LIMITED	Madhya Pradesh	HPCL

Table 4.4 Existing Joint Venture Companies

JOINT VENTURE COMPANIES UNDER FORMATION

STATE / CITY	PARTNER
Gujarat	**HPCL**
Rajasthan	**HPCL**
West Bengal	**IOCL**
Kerala	**BPCL**
Karnataka	**BPCL**

Table 4.5 Joint Ventures under formation

	Primary Focus	CNG Stations	Households	Commercial units	Industrial units
IGL	CNG	146	57,000	280	-
MGL	CNG & PNG (D)	125	270,000	790	40
GGC	PNG (I) & PNG (C)	16	170,000	2,200	650
AEL	CNG, PNG (I) & PNG (C)	35	5,000	80	230

Table 4.6 Current Status of CNG & PNG in India

4.4 AREAWISE CITY GAS DISTRIBUTION IN INDIA

City gas distribution (CGD) is fast emerging a profitable business proposition with networks in 25 Indian cities operated by dozen-odd companies. And this seems just a beginning as big players like Reliance Industries are planning an entry in this sector in a big way. Domestic gas transport company GAIL (India) Ltd has a presence in the CGD business through seven joint venture companies. It is also the first Indian company to foray into China's gas sector through its alliance with China Gas Company for CGD projects.

4.4.1 DELHI CITY GAS DISTRIBUTION NETWORK

GAIL launched a pilot project in 1992 for supply of CNG to the transport sector in Delhi. GAIL installed nine CNG stations in Delhi. Out of these nine stations, one was built on Gail's own land and the remaining eight were on Oil Marketing Companies retail outlets. There were about 2000 vehicles running on CNG in Delhi till 1998. After the formation of IGL, the above projects of GAIL were transferred to IGL. As on February 1, 2005, IGL had a total of 128 CNG stations. Out of these, 59 were Mother Stations, 32 were Online Stations, 35 were Daughter Booster Stations and 4 were Daughter Stations. Two of the CNG stations have been set up at Noida. A total of 92,916 vehicles were running on CNG as on January 1, 2005. IGL's CNG customers include owners and operators of public transport buses, tourist taxies, phatphat sewa vehicles, private vehicles etc. Delhi Transportation Corporation (DTC), which operates public transport buses in Delhi, is IGL's largest customer. Delhi has the largest fleet of buses running on CNG in the world. The total compression capacity as on February 1, 2005, was 16.48 lakh kg/day based on 18 hours/day operation. The total number of compressors commissioned till February 1, 2005 were 120. IGL's total CNG sales in January 2005 was about 0.846 million kg/day. IGL proposes to set up 30 gas stations in the year 2005, targeted at private cars, which are yet to switch from petrol and diesel to CNG. As on January 1, 2004, IGL had a pipeline infrastructure of 137.66 km for supplying CNG.

			PILOT PHASE (END '98)	PRESENT (End Jan'06)
➢ NO. OF STATIONS				
	MOTHER	:	1	62
	ONLINE	:	3	43
	DAUGHTER	:	5	04
	DAUGHTER BOOSTER	:	-	33
	TOTAL	:	9	142
➢ COMPRESSION CAPACITY (LAKH KGS/DAY)		:	0.20	18.39
➢ NOS. OF CNG VEHICLES (APPROXIMATELY)		:	1200 (4)	105,949 (10,829)
➢ AVERAGE CNG SALE, (LAKH KGS/DAY)		:	0.03	8.67

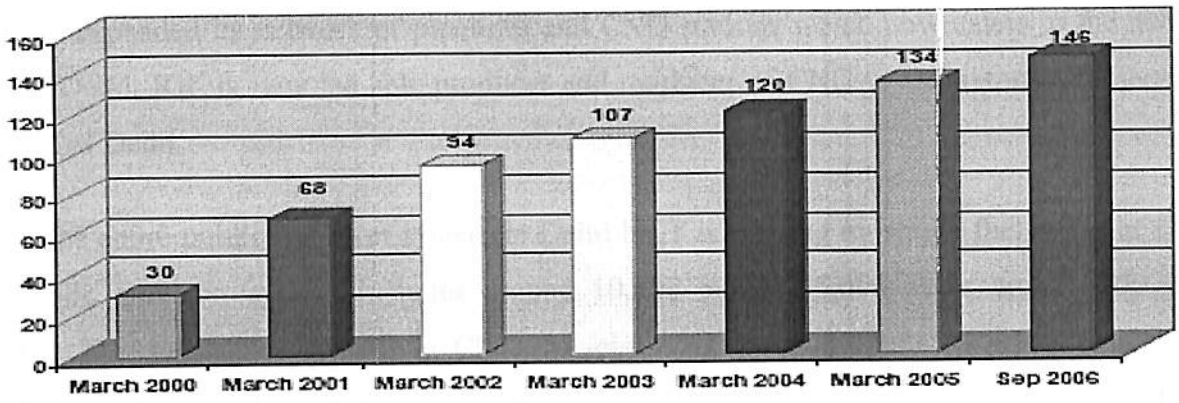


Fig 4.3 CNG stations growth in Delhi

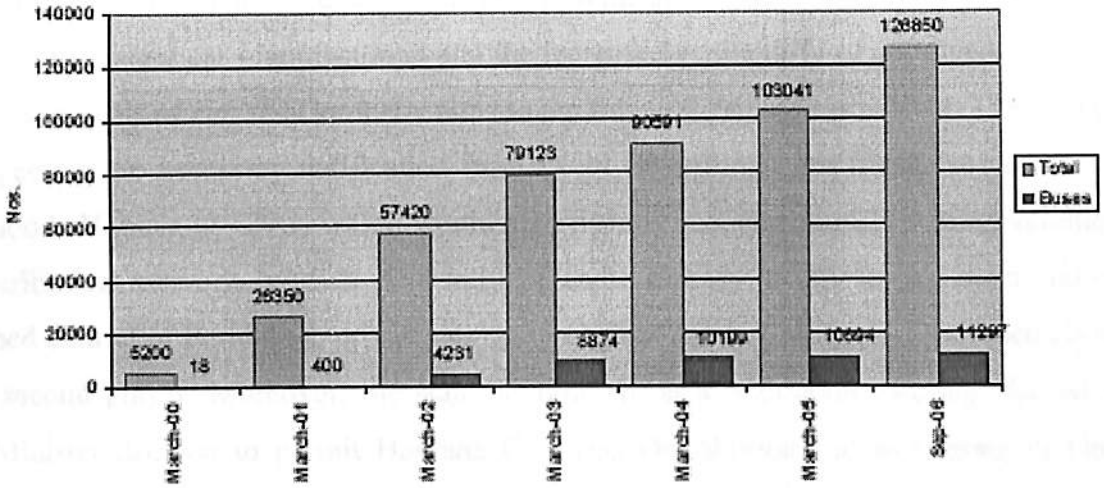


Fig 4.4 Growth of vehicles using CNG

The inflection point for natural gas in India came after the Supreme Court's directive of April 5, 2002 when CNG was mandated as a fuel for public carriers in 11 cities with an aim to control pollution levels. The existing set of players in the industry, apart from GAIL, includes Bhagyanagar Gas in Andhra Pradesh; Gujarat Gas Company in Surat, Ankaleswar and Bharuch; Gujarat State Petroleum Corporation in Hazira; Gujarat Adani Energy in Ahmedabad. In fact estimates CGD networks in India have the potential to use up to 17.3 mmscmd (million metric standard cubic meter per day) by 2011 from 38 identified cities.

Indraprastha Gas caters to the needs of Delhi NCT

In 1999, Indraprastha Gas Ltd started a network with only nine CNG stations set up by GAIL as part of a pilot programme of the Delhi City Gas Distribution Project. In a span of 56 months, the

company expanded its network of pipelines and CNG stations which now caters to the need of NCT of Delhi. IGL is now the sole producer and marketer of CNG to the automotive sector in the NCT of Delhi.

Today, the entire public transport system in Delhi NCT is running on single fuel mode of CNG. The public transport system includes around 10,500 buses, 65,000 autos and 20,000 other vehicles. The substantial growth in CNG vehicles took place in 2002-03 when majority of vehicles running in public transport system got converted from diesel/petrol to CNG. IGL has plans to roll out infrastructure in the national capital region of Delhi, which includes Gurgaon, Noida, Greater Noida, Faridabad and Ghaziabad. With the introduction of CNG variant models by leading passenger car manufacturers and the increased availability of approved CNG Kits for all popular models of car, the Company aims to tap this vast private car market. The Company is also expecting the necessary notification from Delhi Government for mandatory conversion of Light Goods Vehicle to CNG, which would significantly increase the CNG sales volume. As a gas distribution network by Gas Authority of India already exists in the most industrially developed district of Faridabad, private company Gujarat Adani Energy Ltd had been allowed to be the second player. Moreover, the state government at a high-level meeting chaired by the Chief Minister decided to permit Haryana City Gas Distribution Ltd to operate in Gurgaon, another district that has witnessed substantial industrialization.

Future Plans

IGL is presently supplying CNG and PNG to NCT of Delhi. The compression capacity of IGL will be increased to 18-lakh kg/day from the present 16.48 lakh kg/day. The Company has drawn out plans to consolidate its presence in the city of Delhi by investing Rs. 947 million during the financial year 2005-06 for CNG expansion. The oil ministry has allocated 0.7 MMSCMD of natural gas for Delhi. CGD networks will be implemented in phases in the three cities. Under Phase-I, IGL plans to set up about 20 CNG stations in three years time, subject to approvals from government. The CNG station infrastructure in Delhi is supported by a network of 150 km of Steel pipeline and 500 km of Medium Density Polyethylene (MDPE) pipeline. The compression capacity as on date is 17.34 lakh Kgs/day. The infrastructure created provides comfortable fuelling experience to around 94,000 vehicles, which include about 10,480 buses, the largest bus fleet running on CNG anywhere in the world.

As per the report on "Cost Benefit Assessment of CNG introduction in Delhi" by Consultancy Development Center (CDC), an autonomous institution promoted by DSIR, Ministry of Science and Technology, the use of CNG in Delhi has led to a reduction in SO2 levels, Suspended particulate matter, Respirable suspended particulate matter, Carbon Monoxide, Benzene and Polyaromatic Hydrocarbons.

4.4.2 MUMBAI CITY GAS DISTRIBUTION NETWORK

In the early 1990s, the Government of India permitted GAIL to execute the CGD project in Mumbai and allocated 1.5 MMSCMD of gas for this purpose. This supply of 1.5 MMSCMD of natural gas was to be sold as follows:

Sector	Consumers	Allocation in %
Domestic	6,26,000	32
CNG Vehicles	20,000	12
Commercial	4,500	8
Industrial	146	48

Source: Report of the Committee on City Gas Distribution in Mumbai

Mahanagar Gas Limited (MGL)

In May 1995, Mahanagar Gas Limited (MGL), a joint venture of GAIL, BG India and Government of Maharashtra, was incorporated taking into consideration the requirement for technical know-how and foreign equity for setting up India's first metropolis CGD project and to comply with FIPB approval (February 1994). The company got permission to commence business in July 1995 and since then it has put in place the CGD network in Mumbai. MGL is the largest CGD Company of India and fuels about 40% of CNG vehicles in India.

The Gas Supply Contract signed between GAIL and MGL provided for allocation of 1.5 MMSCMD of natural gas to MGL in a phased manner. The contract provided that initially the company would draw gas only to cater to domestic, commercial and transport sectors until it achieved sales of 0.778 MMSCMD of gas to these sectors. After achieving this target of 0.778 MMSCMD, the allocation was to be increased to 1.5 MMSCMD, out of which MGL could sell

some gas to industrial consumers. However, since the cost incurred by MGL was much more than the revenue generated from the domestic sector, the oil ministry permitted MGL to supply 0.04 MMSCMD of gas to the industrial consumers prior to achievement of gas sales of 0.778 MMSCMD subject to the condition that 3000 domestic consumers were connected. The supply to industrial customers was further permitted to 0.1 MMSCMD (upon achieving 8000 domestic connections) and then to 0.3 MMSCMD (after achieving 100000 domestic consumers) and finally to 0.4 MMSCMD (against the achievement of 200000 domestic connections). In December 2004, the average sale of natural gas by MGL was around 1.1 MMSCMD.

The company had 114 CNG stations as of October 2005, out of which 4 are Mother Stations, 97 are Online Stations and 13 are Daughter Booster Stations. A total number of 158555 vehicles were running on CNG in Mumbai as of October 2005. The average sales of CNG in the month of September 2005 was 587359 Kg/day i.e. 850013 SCMD.

Table 4.7 CNG stations in Mumbai (As of October 2005)

Stations	MGL/Pvt owned	IOCL	BPCL	HPCL	IBP	BEST	Total
Mother	3	-	-	-	-	1	4
Online	6	11	36	37	6	1	97
Daughter Booster	0	1	8	4	-	-	13
Total	9	12	44	41	6	2	114

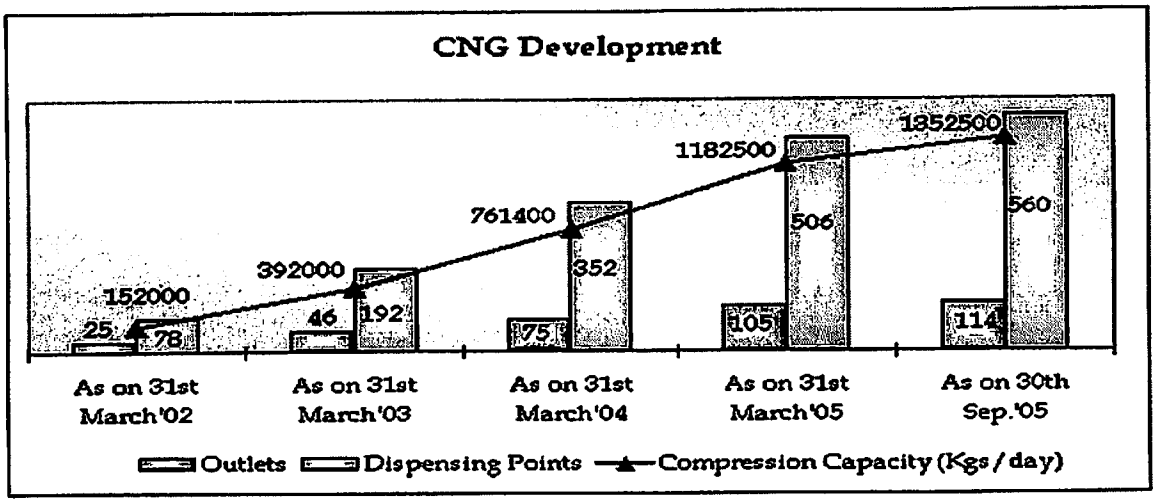


Fig 4.5 CNG Development in Mumbai

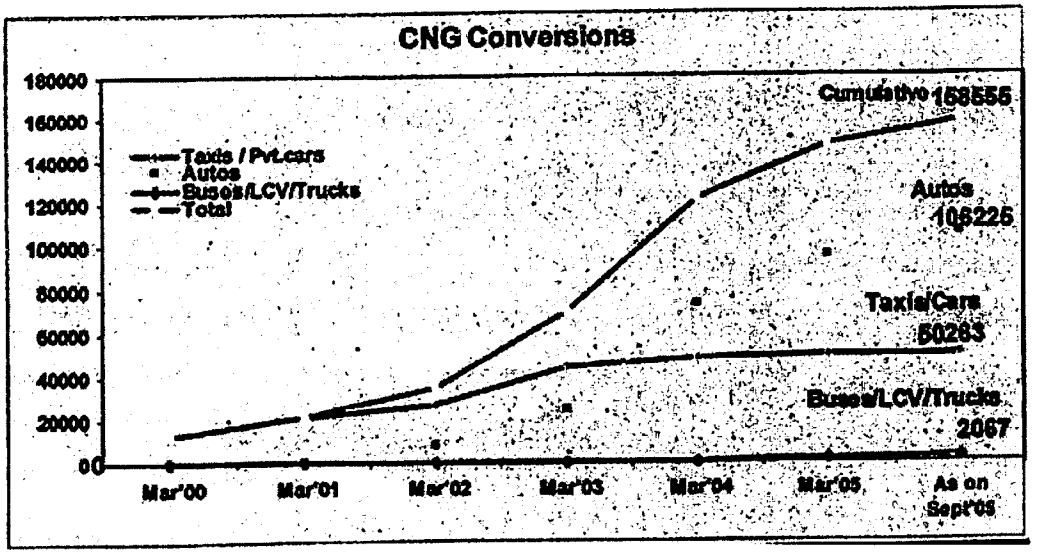


Fig 4.6 CNG Conversions in Mumbai

CONSUMER BASE OF MGL

- Domestic Consumers: 2,20,000 nos.
- Commercial Consumers
  - Category 'A': 546 nos.
  - Category 'B': 133 nos.
  - Category 'C': 20 nos.
- Industrial Consumers: 47 nos.
- CNG Outlets: 117 nos.
- CNG Vehicles: 1,67,000 nos.

Future Plans of MGL

MGL is planning to expand its retail gas distribution business around Mumbai. The oil ministry has allocated 0.5 MMSCMD of natural gas for Thane and Navi Mumbai. MGL has chalked out a Rs 6 billion expansion plan to enter six locations- Mira Road- Bhayander area, Kalyan-Dombivili, Thane-Belapur, Vashi, New Mumbai belt and Taloja. The demand assessment for all these locations has been completed. MGL plans to set up 5 CNG stations in Thane and Mira Road-Bhayander area and around 50 CNG stations in the six locations in next two to three years subject to availability of land, required permissions and CNG related facilities. It expects to increase the number of CNG stations in Mumbai to 200. It has also sought details for areas such as Khadki and Chinchawad near Pune where it expects to enter into PNG distribution. MGL is negotiating for additional gas requirement with Shell and Petronet LNG to source gas from Hazira and Dahej LNG

Gail's future plans

GAIL has already established the city gas business successfully in Mumbai, Delhi, Vadodara, Vijayawada, Agra, Lucknow and Kanpur through seven joint venture companies, namely Mahanagar Gas for Mumbai, Indraprastha Gas for Delhi, Bhagyanagar Gas for Andhra Pradesh, Tripura Natural Gas Company for Agartala, Central UP Gas for Kanpur, Green Gas for Lucknow and Agra, and Maharashtra Natural Gas for Pune for implementation of city gas projects Moreover, GAIL is in the process of formation of state wise joint ventures for implementation of city gas projects in the states of Madhya Pradesh, Rajasthan, Gujarat, West Bengal, Kerala and Karnataka along with the oil marketing companies . GAIL has identified major cities across the country based on the Supreme Court orders and business fit cases. The names of the cities apart from Mumbai and Delhi are Agra, Kanpur, Lucknow, Faridabad, Pune, Patna, Varanasi, Ahmedabad, Sholapur, Hyderabad, Bangalore, Chennai, Kolkata, Bareilly, Rajahmundry, Vijayawada, Vadodara, Navi Mumbai and Thane, NCR cities (Gurgaon and Noida) Allahabad, Jhansi, Mathura, Gwalior, Indore, Ujjain, Rajkot, Surendranagar, Kota. The implementation of city gas projects in these cities is linked to availability of gas. Most of the cities are expected to be implemented by 2009.

BPCL and GAIL set to float JV for distribution of gas in Maharashtra

- State-run oil refining and marketing company Bharat Petroleum Corporation (BPCL) is set to float a joint venture with GAIL India for distribution of gas in Maharashtra, excluding Mumbai. The company is to be registered under the name of Maharashtra Natural Gas Limited (MNGL). Both BPCL and GAIL are expected to hold 22.5 per cent stake in the company each, and 5 per cent of the stake would rest with the state government or its nominees. The remaining 50 per cent was likely to be financed either through a financial institution or an initial public offer.
- The demand for natural gas in Pune would be anywhere between one and two million cubic meters, according to studies conducted by Bharat Petroleum Corporation. This is comparable with the usage in Mumbai. The company is looking to source gas from Dabhol, Dahej, Krishna Godavari Basin and Bombay High.
- The project is likely to go on floor by late 2006, or early 2007, said the company executive. Further, the Supreme Court, through a directive, proposed that Pune, being a growing polluted city, should be the destination for setting up the joint venture company, to distribute natural gas.
- MGNL will be able to supply gas to all centers in Maharashtra, except Mumbai, where Mahanagar Gas undertakes the distribution.

4.4.3 GUJARAT CITY GAS DISTRIBUTION NETWORK

Gujarat Gas Company Ltd. (GGCL), promoted by British Gas, has developed CGD networks in Ankleshwar, Baruch and Surat. It is India's first and largest private sector gas distribution company and has its base in one of the most industrialized belts of the country (Surat-Vadodara-Ankleshwar), called the Golden Corridor of Gujarat. As on December 1, 2004, the company had five CNG filling stations in Surat and one CNG station each at Ankleshwar and Baruch. It operates a 1600 km independent network of pipelines for supplying PNG to industrial, commercial and domestic customers in Southern Gujarat. As on December 15, 2004, GGCL was distributing 0.2 MMscmd of gas and transporting more than 0.3 MMscmd of gas through its pipeline network to 140,166 domestic, 1758 commercial, 443 industrial and 1347 CNG customers in Ankleshwar, Surat, Bharuch and surrounding industrial estates. GGCL plans to invest Rs 1 billion over the next five years to set up CNG stations in Ankleshwar, Surat and

Baruch. The investment will be made in phases. In the first phase, the company will invest around Rs 100 million to set up five CNG retail outlets in the three cities. GGCL also plans to extend its CGD business to three cities outside Gujarat.

Gujarat State Petroleum Corporation Ltd. (GSPCL) plans to set up a chain of CNG stations across the state. As a pilot project, GSPCL has already set up and operationalized a CNG refueling station near Ichchapore village on Surat-Hazira road with a capacity of 1500 kg. The refueling station offers maximum possible value added services and is called the 'Synergy Station'. It now plans to set up 175 CNG stations along National Highway 8 between Surat and Mehesana in a phased manner. Out of these CNG stations, 17 will be highway stations and 158 will be city stations, which will be set up over the next three years. The total cost of the project is estimated to be Rs 3.1 billion. This will cover cities like Surat, Bharuch, Vadodara, Anand, Nadidad, Ahmedabad, Gandhinagar and Mehsana. GSPCL has signed a MoU with HPCL to set up a chain of 246 CNG dispensing stations along the highways between Hazira and Mehsana by the end of year 2004. A MoU was also signed with GGCL for the development of CNG business in the Surat-Ankleshwar belt in February 2001.

Gujarat Adani Energy Ltd. (GAEL) was awarded distribution circles in Ahmedabad and Vadodara in April 2003. GAEL is the second private company after GGCL which is setting up city gas distribution infrastructure in Gujarat. The project envisages constructing a 1600 km distribution network in Ahmedabad and Vadodara at a cost of Rs 3.25 billion. GAEL's customers are expected to include 150 industrial units, 2000 commercial establishments, 250,000 houses and 40,000 vehicles. Initial demand is estimated at 1.8 MMscmd. In September 2004, GAEL commissioned first phase of its CGD project in Vadodara. On September 27, 2004, it launched commercial operations by supplying PNG to industrial customers through its 13 km pipeline from Nandesari to Ranoli in Vadodra. In September 2004, the average supplies were around 0.005 MMscmd. GAEL is offering natural gas to its customers within a price band of Rs 8.70 to Rs 9.20 per cubic meter depending on the pressure at which the customer desires to receive the gas. It expects to supply 0.3 MMscmd to its customers through this pipeline by March 2005. In Vadodara, GAIL also supplies CNG to consumers and operates two CNG stations- one-daughter station in Vadodara and one mother CNG station in Vaghodia. GAIL has also set up five CNG stations- two-mother stations and three daughter booster stations in Vadodara by June 2005.

On December 31, 2004, GAEL launched its CNG network in Ahmedabad by operational zing CNG station at Maninagar. Later, it started the CNG station at Naroda. A third CNG station is expected to be operationalised soon in Jamalpur. All the three CNG stations have a capacity of 1200 cm/hour. GAEL plans to set up five more CNG stations by March 2005, which include 1200 cm/hour at Paldi and 650 cm/hour capacities each at Vasna, Wadaj, Sarkhej-Gandhinagar highway and Prahaladnagar. It proposes to set up another 19 CNG stations in Ahmedabad in 2005.

Earlier, GGCL wanted to develop gas circle in Ahmedabad but failed to get "no objection certificate" under Gujarat Government's Interim Gas Policy (now declared unconstitutional). GAIL, BPCL and IOC also expressed interest in forming joint venture with GAEL. In December 2003, GAEL decided not to have a 'strategic partner' for the gas distribution projects. In December 2003, GAEL also signed a three-year gas sales agreement with GSPCL for the supply of 0.2 MMscmd of gas through its subsidiary's Gujarat State Petronet Ltd. (GSPL) Ahmedabad-Kalol-Vadodara pipeline. GSPCL will supply gas from its Hazira field at a fixed rate of USD 3.45 per MMBtu. Both GAEL and GSPCL are competing with each other to supply gas to high value industrial customers in Ahmedabad. Initially, GAEL planned to start marketing of CNG and PNG in Ahmedabad and Vadodara by end of June 2004 but had to postpone its plan to commission the project as it could not set up CNG station in Vadodara owing to delay from customers to switch over to natural gas.

Bharat Petroleum Corporation Ltd: The BPCL Board in 2004 accorded 'in principle' approval for implementation of the Gas Distribution Project at Gandhinagar, Mehsana and Sabarkantha districts of Gujarat. The Board also approved payment of security deposit of Rs 1 crore to Gujarat State Financial Corporation Ltd. (GSFC).

After obtaining subsequent consent from MoP&NG, Detailed Feasibility Report (DFR) of the project was finalized in November 2004 covering the automobile, domestic, industrial and commercial sectors. Logicon Engineers was appointed for carrying out the DFR. The DFR projected a capital expenditure of Rs 335.77 crores spread over 14 years (Rs 189.40 Crores till 2008 and remaining 146.37 crores during 2008-2018) with project IRR of 15.54%. Estimated Natural Gas requirement as per the DFR is 1.3565 MMSCMD.

BPCL has already sourced 0.55 MMSCMD of gas for the said project. Investment for the implementation of the project has also been started. As on date, gas supply agreements have been signed with ten customers for a period of ten years with commitment of gas supply to the tune of Rs 186 crores during the said period. Gas supply has already begun to four industrial customers in Gandhinagar district from May 2005. A sale during the period of May to August 2005 was 1.3 MMscmd with a turnover of Rs 1.4 crores. Further, commitments have been made towards equipment/material procurement/job execution for works in progress for approximately Rs 18 crores out of which an amount of Rs 42 crores have already been capitalized.

One CNG on-line station is under implementation for dedicated filling of Gujarat State Road Transport Corporation (GSRTC) buses at Gandhinagar. Land for the CNG station has been taken over from GSRTC at a nominal lease rent of Re. 1 one per year for 25 years. BPCL also contemplates to start a CGD network in Santej. Gas from Ahmedabad to Santej will be supplied through an existing 10 km, 12-inch spurline from Ahmedabad to Santej. BPCL will also set up CNG outlets on the highway. It plans to set up at least six CNG stations on Ahmedabad-Sarkhej-Gandhinagar highway. BPCL is sourcing gas from Niko operated Hazira gas field through PLL's pipeline from Baroda to Kalol passing through Ahmedabad.

GSPCL and BPCL have agreed to synergize their resources and strengths to form a Joint Venture Company (JVC) for setting up the infrastructure for distribution and marketing of Natural Gas, Compressed Natural Gas (CNG), Piped Natural Gas (PNG), other gaseous fuels in Gujarat and to start with at Gandhinagar, Mehsana and Sabarkantha districts of Gujarat as well as in Exploration & Production activities.

The proposed JVC will be beneficial to BPCL as GSPCL is abundant with gas finding in Gujarat and is already in gas business. JVC can derive definite advantages such as sourcing of gas, utilization of existing infrastructure and supply of gas to existing customers of GSPCL at Gandhinagar. Accordingly, MoU was signed with GSPCL on September 27, 2005. The Joint Venture Agreement (JVA) is expected to be finalized and executed within a period of six months from the date of signing of the MoU.

Till such JVC is formed and equity and debt arranged, BPCL has sought approval of Board to continue investment up to Rs 50 crores which will be adjusted in equity contribution of BPCL in

the JVC. The Board has granted its approval for the same subject to necessary approval of the Central Government.

Indian Oil Corporation (IOC) plans to enter CNG retail market in major cities of Gujarat. At the outset, it intends to develop CNG retail network in Ahmedabad through a large number of its retail outlets that will be installed with CNG dispensing facilities for vehicles. The existing players view this as a violation of the existing state government guidelines. As per the guidelines, not more than one entity would be issued license for distribution of CNG in one city or town. Licenses have already been issued to private and public companies in all major cities including Ahmedabad and Vadodara. If, IOC is issued a license for selling CNG or any changes are made in the present guidelines, the decision will mainly impact the Adani Group, which has the rights to sell CNG and PNG in Ahmedabad and Vadodara.

Hindustan Petroleum Corporation Ltd. (HPCL) was issued a license by Gujarat government in December 2004 to set up CNG network in Ahmedabad. HPCL envisaged setting up nine CNG daughter stations and one mother station by March 2005. The license was issued despite the assurance by state government to GAEL that no other player will be allowed in this segment. The license has been issued owing to delay on part of GAEL in setting up the distribution network. GAEL has lodged a formal complaint with the state energy secretary for this issue.

4.4.4 AGRA CITY GAS DISTRIBUTION SYSTEM

Due to the industrial and urban growth in the Agra-Mathura region and the resultant rise in levels of environmental pollution, the need to develop CGD network in this region was felt. The rising pollution levels pose a serious threat to the historical monuments located in the area, such as, The Taj Mahal, Sikandra as well as Bharatpur Bird Sanctuary. The main sources of pollution are the SO_2, NOX and SPM emissions from the industries located in Taj Trapezium, viz. Mathura Refinery, Iron Foundries in Agra and Glass Units in Ferozabad. In 1984, Public Interest Litigation was initiated against the Union of India on the above matter before the Supreme Court of India, inter-alia, pleading for suitable measures to save the historical monuments from damage caused by the pollution.

Ten Point Initiative to protect Taj Trapezium Zone

Considering the urgent need to check the environmental degradation, the MOP&NG launched a ten-point initiative in March 1995 to reduce pollution in the Taj Trapezium Zone. Under the programme, the Government of India made an allocation of 1.1mmscmd of natural gas for supply to industries in Agra and Ferozabad. GAIL in Agra, Ferozabad and Mathura in are currently undertaking gas distribution northern India. The project is part of government's ten point of Taj Trapezium to replace the current coal and fuel oil usage in small industry and control the environmental damage in the specially to the Taj Mahal. The project involved laying a spur line over a distance of 92km from HPJ pipe line up to Agra and Ferozabad besides creation of internal distribution network in the two cities to utilize the 0.6 mmscmd of natural gas available for the project.

4.4.5 PROJECT BLUE SKY

Under project Blue Sky, GAIL has initiated steps to implement CGD networks in five cities namely, Kanpur, Lucknow, Agra, Bareilly and Pune. It is planning to invest Rs 5.5 billion in the project. The project will be completed in three to four years time. The company aims to expand retail marketing and distribution of gas in these cities by constructing new pipeline networks and infrastructure for supplying CNG. It will then pipe the gas directly to industries, hotels, homes and CNG stations. GAIL is also looking at involvement of multinational companies in implementing the Blue Sky project. It proposed oil and gas major Shell to participate in the project.

The various CGD networks that are being developed as a part of Project Blue Sky are:

- LPG for households;
- Unleaded/Low Lead Petrol;
- Preferential allocation of LPG for Industries;
- Supply of Low Sulphur HSD in Taj Trapezium Area;
- Intensification of Environment Management by Mathura Refinery;
- Natural Gas for industries in Agra and Ferozabad;
- CNG for vehicles;
- Natural Gas for Mathura Refinery;

- Hydro cracking technology for Mathura Refinery; and
- Identification of alternate strategies for environmental management in consultation with Asian Development Bank.

To put CGD networks in place in Agra and two other cities- Lucknow and Bareilly of Uttar Pradesh, IOC collaborated with GAIL. This also marked the entry of IOC in CGD business. An MOU was signed between GAIL and IOC in May 2004 to set up a joint venture for the distribution of CNG, PNG, Auto LPG and other gaseous fuels in these three most polluted cities of UP. However, after carrying out the detailed feasibility study, IOC decided to shelve the plan for setting up CGD network in Bareilly. IOC and GAIL have formed a joint venture for implementing the projects in Agra and Lucknow in which both will hold 22.5% equity each. The strategic investor and financial institutions will hold 50% while the state government of Uttar Pradesh will acquire the remaining 5%. The joint venture will take the Lucknow project on pilot basis. The project will see an investment of USD 480 million for Agra and USD 210 million for Lucknow. The gas will be supplied from PLL's Dahej LNG terminal through the HVJ pipeline. A branch pipeline will be laid from Jagdishpur to Phulpur for supply to Agra and Lucknow. According to a detailed feasibility report on Agra, Lucknow and Bareilly, GAIL estimates 1000 domestic piped natural gas consumers and demand for 100 CNG stations. GAIL has set aside 1.1 MMscmd for Agra and 0.1 MMscmd for Lucknow.

Gas Supply to Agra & Ferozabad Industries

Table 4.8 Action taken by GAIL and MoP&NG

Allocations made	1.1 MMscmd
Expenditure made	1.125 billion
Additional Expenditure Planned	260 million
Length of Pipeline	92 km
Industries Covered	Glass, Leather, Iron, Foundries etc.

Table 4.9 CNG Stations Planned under Phase-I of Project Blue Sky

City	No. of Stations
Lucknow	2
Agra	7
Bareilly	2
Kanpur	11
Pune	29

4.4.6 CGD NETWORK IN PUNE AND KANPUR

The city gas distribution projects in Pune and Kanpur were awarded to GAIL and BPCL. In July 2004, GAIL and BPCL finalized plans to set up separate companies for the two projects with BPCL and GAIL holding 22.5% stake each, the state government holding 5% stake and the financial institutions holding the rest 50%. These projects will together require an investment of about Rs. 8 billion. On July 26, 2004, Pune Gas Ltd. was formed to implement CGD network in Pune and the adjoining areas of Pimpri and Chinchwad. The Pune project will require an investment of Rs 6 billion. It will be implemented in two phases. The first phase that would be completed in three years will involve the creation of the infrastructure for gas transportation. In the second phase, actual supplies would begin. This phase would take about six to ten years. It is estimated that there are 100 industrial, 1700 commercial and 320,000 domestic consumers in Pune that will consume 0.3 to 0.4 MMscmd of gas in the initial stages. The Gas Linkage Committee has allocated 0.4 MMscmd of gas for the Pune project. The gas use is expected to increase to 2 MMscmd in next seven to eight years.

The gas would be supplied to Pune through the Dahej-Uran pipeline, which would be extended to Chikali, near Pune. Natural gas would be supplied to Kanpur by laying a 12-km feeder pipeline connected to the HBJ trunk pipeline. The city gas project would use R-LNG from Dahej LNG terminal. GAIL and BPCL are also conducting talks with Reliance India Ltd. for supply of

natural gas from its discovery in the KG Basin for Pune project to meet the increasing demand of gas later as the project progresses.

GAIL and BPCL have set up a joint venture, U P Gas Ltd, for implementing CGD network in Kanpur. The oil ministry has allocated 0.1 MMscmd of natural gas for the CGD project. The demand for CNG and PNG is expected to increase from 0.028 MMscmd in 2005 to 0.2 MMscmd in 2007. The company plans to set up one mother, one online and one daughter booster stations in Kanpur in 2005. These will be increased to two mother and online stations each and four daughter booster stations by 2007.

In April 2004, there was dispute between GAIL and BPCL over the leadership of the projects. GAIL wanted to lead both the projects while BPCL wanted to lead the Pune project. GAIL also desired that Mahanagar Gas Ltd. to included in the Pune project while BPCL was against this. Finally, it was agreed by the two companies that MGL will not be an equity partner of the joint venture company, Pune Gas Ltd. This was considered as the violation of the directive issued by the oil ministry in April 2004 that the CGD project at Pune will be implemented by a joint - venture between GAIL, BPCL and MGL. To honour the directive of oil ministry, BPCL agreed to include MGL as the technology partner for the project. MGL will act as the technology advisor for the project and carry out detailed research on the consumer market for the industrial and the commercial gas.

4.5 FURTHER DEVELOPMENTS IN CGDs IN INDIA

- 40 cities (including existing cities) identified for implementation of city gas projects in XI - 5 year Plan
- Demand for these 40 cities is estimated to be 15.8 MMSCMD by 2011- 12 and 23.3 MMSCMD by 2016-17
- Natural gas companies have identified additional 74 new cities with estimated demand of 11 MMSCMD by 2011-12 and 15 MMSCMD by 2016-17
- There have been reports of India having CGD potential of 200+ towns/cities in the medium/long term.

- These city gas projects will be connected with the existing pipeline network and the new pipelines expected to come up in the next 5-10 years

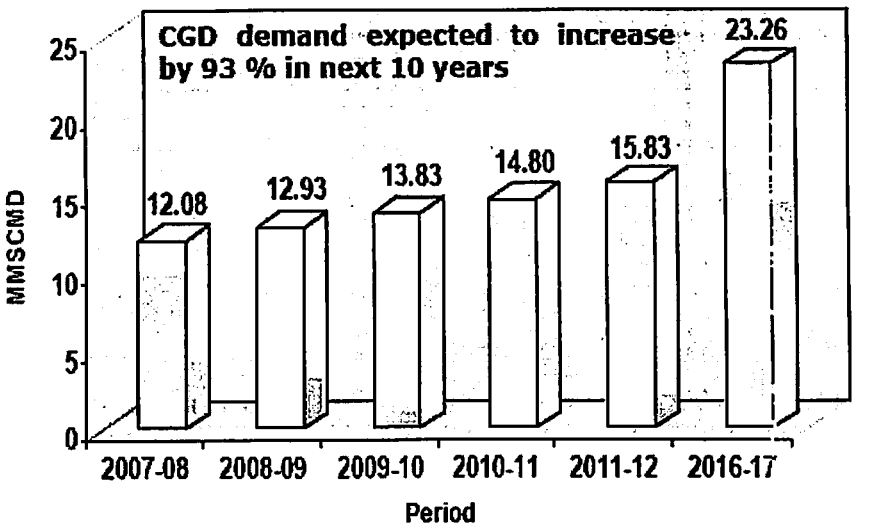


Fig 4.7 CGD Demand Projections for 40 cities

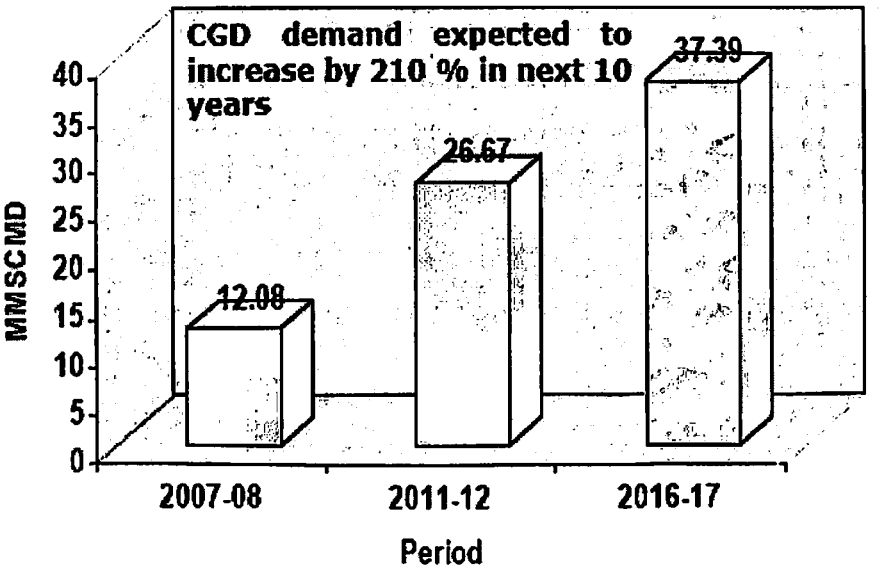


Fig 4.8 CGD Demand Projections for 114 cities

4.6 CITY GAS IN INDIA – OPPORTUNITIES & CHALLENGES

4.6.1 CITY GAS IN INDIA – EMERGING OPPORTUNITIES

- New **Supply Sources** like K-G Basin by companies like Reliance, GSPC etc.
    - It creates potential to distribute gas to metros in close proximity to trunk pipelines carrying K-G basin gas.
- **Supply Sources** like LNG existing in PLL and Shell, Hazira. Future sources of LNG are Kochi and Dabhol, Mangalore and Ennore are still in the planning stage.
    - It creates potential to distribute R-LNG along HBJ pipeline.
    - New metros like Kochi, Dabhol etc will be on the gas map.
- **Pipeline infrastructure** is improving with new trunklines being laid by Reliance, Gail, Shell, and GSPC across various markets which would provide connectivity to existing / new markets.
    - It creates potential to distribute gas to metros in close proximity to trunk pipelines carrying K-G basin gas.
- **Government Regulation** – Supreme Court in August 2003 issued a directive to Union of India and state governments to draw plans to introduce clean fuels in 11 cities other than Delhi & Mumbai.
    - It creates a potential to set up new companies.
- **Government Regulation** – Exclusivity in allowing a single company to distribute Natural Gas in a particular city for certain number of years.
    - It allows new players to enter existing lucrative markets.
- **Government Regulation** – Providing excess capacity in the trunk pipelines.
    - It creates potential to distribute gas to metros in close proximity to trunk pipelines.
- **Local Government Regulations** – Local government mandate for conversion of public transport to CNG.
    - It increases the market depth for the existing players.
- **Innovative transport solutions** such as CNG for short distance trains and CNG run forklifts.
    - It creates new markets for the existing players.

- **Active Participation by OEMs** by fitment of kits in OEM approved workshops and launch of new CNG variants at factories.
    - It increases the market depth for the existing players.
    - It will benefit already established companies.
    - The benefit to customer is that warranty is assured.
- **Multiple Residential uses** like
    - It is used for cooking purpose at present.
    - Combined Gas heating and cooling systems.
    - Combination space and water – heater systems.
    - MICROTURBINES
    - GAS GRILLS AND LIGHTS
    - STACKED WASHERS AND DRYERS
- **Commercial / Industrial Applications** like combined heating & power (CHP) and combined cooling, heating and power (CCHP) systems.
    - It increases the market depth for the existing players.
- **Industrial Applications** - Preferred fuel in generating electricity because of low pollution levels and versatility in use.
    - It provides an opportunity to form Joint ventures with power generating companies.
- **Diversification into Telecom Infrastructure**
    - Lay optic fiber cables along with steel / MDPE network.
    - It operates as an integrated telecom infrastructure provider.
    - It generates additional revenue by sharing infrastructure.
    - It increases income and profit for the existing player.
- **Partnership with local government**
    - Multiple applications like Community kitchens, public schools (cooking purpose), incinerators, crematoriums etc.
    - It provides an opportunity to provide natural gas to new market segments.

4.6.2 CITY GAS IN INDIA – CHALLENGES

- **Gas sourcing** is the biggest challenge
  - Natural Gas Demand far exceeds the supply.
  - APM Gas is limited and used mainly for fertilizers and power.
  - R-LNG supplies from Dahej are tied-up.
  - Spot R-LNG has emerged as one of the options.
  - Gas from new finds yet to be monitised.
- **Laying of Pipeline Infrastructure**
  - Permission from multiple agencies is required.
  - Permission is not given during monsoon season.
  - Delays in permissions lead to cost overruns.
  - Compelled to avoid other underground pipeline / cables.
- **Setting up of CNG infrastructure**
  - Difficult to obtain lands in metros.
  - Need to focus on OMC outlets to augment stations.
  - Pipeline infrastructure pre-requisite for setting up online / mother stations.
  - Stations have to be closer to Bus terminal locations.
- **State Government Tariffs**
  - Taxes on Natural gas vary from 4% to 20%.
  - Other tariffs such as entry tax, Octroi add to cost of gas.
  - CNG is not exempted in all states.
- **Operational Issues**
  - Pipeline balancing and minimization of losses.
  - Develop Gas loops to reduce pressure drop in the pipelines.
  - Ensure equipment availability of atleast 95%.
  - Compliance with new regulations. E.g. Weights and Measures, Excise duty classifications etc.
  - Ensure safety of pipelines

CHALLENGES IN PNG RETAIL

- RWA & Individual Users
- High Installation charges
- Non – transferable connections

CHALLENGES IN CNG RETAIL

- **Size of the CNG station** - 36x30 Sq. meter norm for MS / HSD retail outlet currently is being offered for CNG stations
    - CNG is manufactured at the point of consumption unlike MS / HSD which is the final product.
    - Natural Gas compressing equipments require much bigger space.
    - The storage tanks at MS / HSD retail outlets are located underground.
    - Passengers are required to alight from the vehicles during refueling.

RETAIL CHALLENGES

- **Is one person per dispensing point as at MS / HSD retail outlets the solution for queue less operation?**
    - Skewed filling pattern
- **Is increasing availability of the product CNG to increase the market share?**
    - Availability of supporting infrastructure like genuine cylinder, kits and spare parts to be used for CNG vehicles.
    - CNG type approvals for all vehicles.
    - Easy availability of spare parts at reasonable rates.

LOGISTIC CHALLENGES

- **Is market survey / demographic survey sufficient to decide on the necessary CNG dispensing facility across the city?**
    - Availability of Land
    - Distance from the nearest pipeline
    - Necessary Government approvals
- **Do CNG stations at regular intervals provide a better spread for the CNG customers?**
    - Enroute filling is not preferred by customers.

CHAPTER 5: COMPARISON OF DEVELOPED AND MATURED GAS MARKETS WITH REGULATORY FRAMEWORK OF INDIAN GAS MARKET

Quite often exploration and production of gas is linked to oil production. However, transportation and distribution of gas are technically different from that of oil, but technically similar to electricity. Gas transmission includes bulk purchases of gas from producers (often using long-term contracts); transport over high-pressure pipelines; storage for load-balancing or strategic purposes; and bulk sales. Distribution includes delivery of gas through low pressure pipelines to final consumers (residential, commercial and industrial), as well as metering, billing and accounting services. Apart from natural gas supplied through high-pressure pipelines, liquefied natural gas (LNG) can be transported large distances. Within the APEC region, Japan and Korea import most of their gas as LNG from Indonesia, Malaysia and Australia.

Gas markets usually consist of vertically integrated monopolists in production, transmission and distribution. Recent policy developments in the gas sector include unbundling of the gas utilities to separate competitive segments (production and distribution) and establishing rules on third-party access (TPA) to the distribution grid. Deregulation of the US gas industry occurred in the early 1990s. Privatization of the UK monopoly, British Gas (BG), in 1986 preceded gas market liberalization and introduction of competition in production and distribution, and establishment of rules on access to the transmission network.

5.1 REGULATION OF THE GAS SECTOR: WHY AND HOW?

The electricity and gas sectors exhibit natural monopoly characteristics, including economies of scale and scope, presence of network externalities and lumpiness of investment due to technological constraints. Consequently, it is necessary to regulate energy services to prevent utilities from abusing market power. The types of market failure that require regulatory interventions are:

- Market power;

- Information asymmetry;
- Externalities;
- Social distributive goals (equity)

Economic theory suggests that an unregulated monopolist will price discriminate if possible to collect monopoly rents. The level of output is lower than socially optimal, and the price higher. This translates into monopoly rents and deadweight welfare losses for the economy. The regulator needs to impose conditions to make the monopolist operate at socially optimal outcomes. However, this is not always possible in practice due to problems of information asymmetry and the possibility of regulatory failure. Market power exists when a firm's unilateral actions change prices. Such a market is not perfectly competitive and the firm is no longer a price-taker, but a price-setter. Firms exercising market power are engaging in anti-competitive conduct. It can be unilateral or multilateral, and also horizontal (within the same market) or vertical (upstream-downstream activities). Anti-competitive practices within the same market include price fixing, exclusionary practices, predatory pricing and market division. Vertical anti-competitive practices in a supplier-distributor chain include exclusive dealing, price discrimination and full line forcing (the obligation on a buyer to purchase a hole line of products rather than just one particular product).

Many issues must be resolved to determine whether conduct is anti-competitive. Fundamental is defining the relevant market and assessing the degree of competition within this market. The "Small but Significant Non-transitory Increase in Price" (SSNIP) test is used in Australia to test whether the market is effectively competitive. Effective competition exists where profits would be expected to fall following a small price increase.

5.1.1 MARKET DIMENSIONS RELEVANT TO DEFINING THE RELEVANT MARKET ARE:

- Product (end use and potential substitutes; product characteristics; costs of switching; past consumer behavior (substitution); costs of switching production and distribution to a close substitute; past behavior of suppliers (substitution); relative price levels and dynamics versus potential substitutes; degree of product differentiation);

- . Geographic (the physical area of competition); access to alternative sources of supply; costs of switching to an alternative supplier; past consumer behavior (switching); transportation costs; perishability; regulatory constraints and switching costs to supply in different geographic areas; past behavior of suppliers and relative prices by geographical sources of supply);
- . Functional and time dimensions (substitutability of retail products for wholesale, market dynamics and future substitutes; whether there is a cluster market with products traded as a group).

Once determining that particular conduct is anti-competitive, the regulator must take appropriate regulatory action to prevent such conduct and to maintain a competitive market. Externalities are also important in the energy sector. Many of the extraction, generation and transportation activities pose potential industrial pollution and health hazard problems. Consumer well-being or production by other firms may be directly affected by the public utility's actions. Such externalities may be dealt with using several instruments, including quotas, taxes or bargaining (that leads to optimal outcomes if property rights are clearly allocated and enforceable - the Coase theorem). Industrial pollution and greenhouse gas emissions present an example of multilateral non-depletable externalities: they have characteristics of a public good (or rather, "bad") in a sense that one party's consumption of pollution does not prevent another party from consuming it (or suffering from it). Pollution control instruments include bargaining, tradable or non-tradable permits (licenses to pollute), imposing minimum technology requirements, relocating affected parties, applying emission taxes or abatement subsidies. Governments should facilitate private bargaining by creating appropriate institutions; defining and allocating property rights; conducting environmental monitoring; maintaining an effective legal system; and promoting social responsibility. Removing distorting duty and tax incentives in sectors from which greenhouse gases are emitted would have a strong effect on reducing emissions. For example, removing global production subsidies alone would reduce total carbon dioxide emissions by an estimated 5%. EU coal producers are heavily subsidized. During the 1990s, the average producer subsidy to the EU coal industry was over one-and-a-half times the coal price. Energy pricing practices in APEC economies appear however to be changing along with market structures towards reflecting true production costs of energy goods and services (APERC (2000a)).

5.1.2 MARKET STRUCTURE OF THE ENERGY SECTOR

Legislation, rules and regulations establishing specific forms of market structure have often impeded competition in this sector. Liberalization of the energy sector should therefore start with legislative changes to make market restructuring possible. As energy markets liberalized globally, vertically integrated monopolists were unbundled into generation (production), transmission (transport), distribution and supply (retail). While the transmission network is uneconomical to replicate (natural monopoly properties), smaller scale generation and distribution is possible, such that competition between firms supplying these activities increases efficiency and lowers prices. Nevertheless, it is still necessary to ensure that the incumbent provider cannot exercise market power, and that a suitable access regime is in place to ensure that both independent producers/generators and consumers/retailers have competitive access to the transmission network.

5.1.3 HOW TO REGULATE THE ENERGY SECTOR?

The regulatory principles need to create a correct set of economic incentives. **Rate-of-return or cost-of-service regulation used in the US** lead to over-investment and a capital-biased input mix (Averch–Johnson effect, Averch and Johnson (1962), Train (1991), Berg and Tschirhart (1988)). Such a regulatory regime creates perverse incentives regardless of whether the rate of return is set above, equal to, or below the true cost of capital. Other forms of regulation capping revenues are better suited to achieve a correct incentives structure.

An alternative approach is to use **incentive-based regulation** such as **revenue or price caps of the "CPI–X" type,** where X could be forward-looking, based on the industry long-term total factor productivity (Vogelsang and Finsinger (1979), Albon (2000), Train (1991)). Price cap regulation allows the utility to raise the weighted average price of a specified basket of services by no more than the increase in the consumer price index (CPI) less a percentage amount, X. Sometimes a retail price index (RPI) is used instead of the CPI, such as in the UK. The X factor creates a strong incentive for the utility to raise productivity, and through a periodic re-assessment ensures these benefits are passed onto consumers. Applying the cap to a basket of products provides an incentive for the utility to remove cross-subsidies and to price discriminate

according to the Ramsey-Boiteux rule whereby price-inelastic consumers face higher prices. Setting a price cap requires an appropriate cost of capital and capital base to be determined. Such calculations are usually based on theoretical assumptions that often become major areas of dispute between the regulator and the utility. A depreciated optimized replacement cost (DORC), equal to the cost of replacement of the existing productive capacity of the depreciated capital stock with the best technology available, can be used by regulators as a measure of the capital stock (Albon (2000)). Calculating the Weighted Average Cost of Capital (WACC) requires knowledge of both the expected rate of return on equity and debt of a particular company. Comparison with other utilities, which is called "yardstick competition", in order to set prices, is another incentive-based regulatory mechanism (ACCC (2000)). It provides an incentive for utilities to lower costs, forcing competition between them for cost reductions. Techniques used to assess utility performance are data envelopment analysis (DEA) and stochastic frontier analysis.

Price regulation in this sector is made more complicated by the presence of externalities in the production and consumption processes. Various policy instruments are imposed as a result and their impact must also be taken into account in setting prices for energy products and services.

5.1.4 BENEFITS OF COMPETITION AND TRADE LIBERALISATION

Competitive markets for goods and services induce firms to improve productivity. This generally lowers consumer prices and results in an expanded variety of goods and services. Pressures on firms to minimize production costs to remain competitive encourage technological and managerial innovations that contribute to productivity growth. Such growth improves the economy's overall efficiency.

A flexible and competitive domestic economy integrated into the international economy is better situated to handle the negative effects of any external shocks. Domestic competition requires liberalized markets that enable enhanced access, reduced barriers to entry by foreign suppliers, and a regulatory framework based on competitive provision of goods and services by entities with different ownership structures, aimed at competitive neutrality.

Developing countries are increasingly recognizing the importance of competition policies. While the same general principles apply, national differences may need to be taken into account in designing a reform program tailored to individual conditions. Regulatory reform to increase competition should precede or coincide with marketing opening measures to allow the benefits of improved resource allocation and expanded consumption possibilities to be maximized. Ahn (2002) comprehensively surveys the theoretical models on relationships between competition, innovation and productivity growth, and refers to numerous empirical studies in various industries, including infrastructure services.

Recent energy sector reforms have concentrated on four main areas: privatization (changing public for private ownership), liberalization (choice of supplier), Price deregulation and competition through unbundling of transmission service and introducing wholesale markets (Haas, Auer *et al.* (2000)). Expected benefits from deregulation in terms of increased management and regulatory efficiency (hence, lower cost) and competitive pressures from other suppliers include lower prices, at least for large industrial consumers, and elimination of cross-subsidization

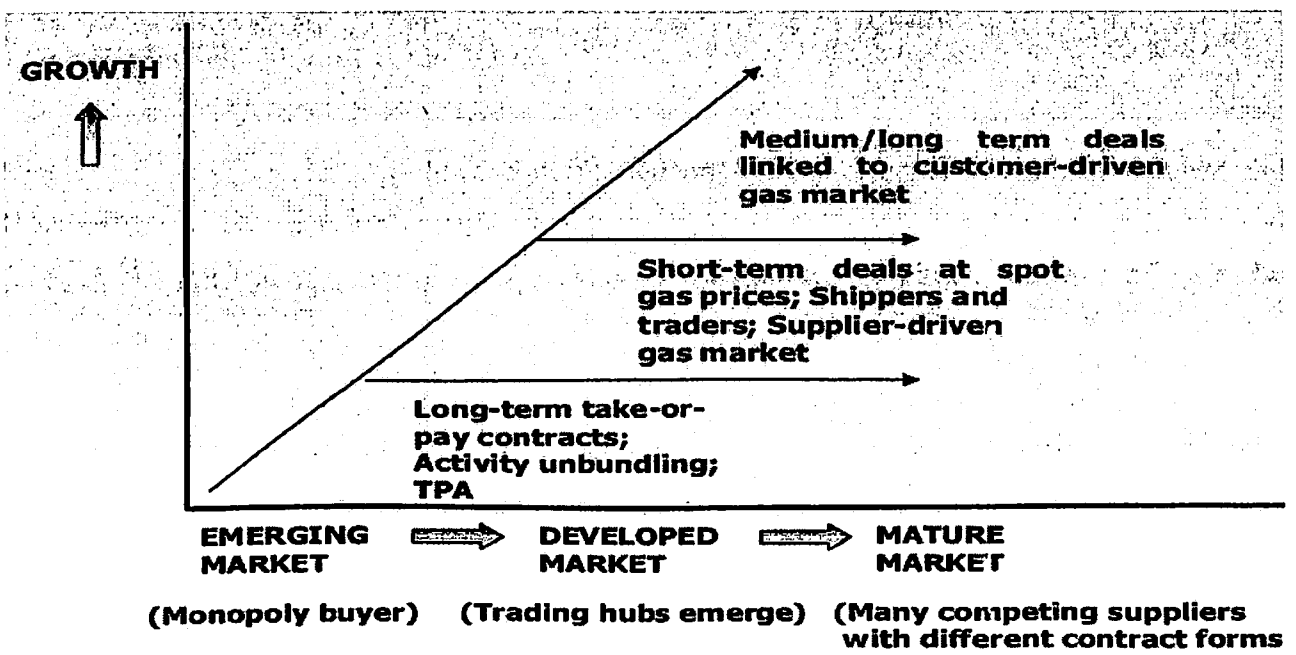


Fig 5.1 POSSIBLE EVOLUTION OF GAS CONTRACTS

5.2 REGULATORY FRAMEWORK OF DEVELOPED GAS MARKETS

The developed gas markets include the following countries like:

- Belgium
- Singapore
- UAE
- Egypt

The gas regulations with respect to transmission and distribution of the developed gas markets are discussed below.

BELGIUM

OVERVIEW OF NATURAL GAS SECTOR:

Belgium is a Federal State consisting of three Regions (the Flemish Region, the Walloon Region and the Region of Brussels Capital) and three communities (the Flemish, the French and the German communities). The regions are competent for economic matters. The Federal State retains the responsibility for, among others, the main energy infrastructures (storage, production and transport), nuclear power generation, the equipment programme for production, transmission and distribution of energy, the control of tariffs and fiscal incentives, the policy for sustainable development, the integration of international obligations, and the industrial and technical norms.

On the other hand, the regions are competent for the local distribution of energy, the management of natural resources, and the development of alternative energy resources including RES, environment, and town planning. The local distribution of natural gas is limited to the supply of natural gas to users with an annual consumption up to 1 million m^3 per site.

Pursuant to the requirement of the Gas Directives to establish an independent dispute settlement authority, the Gas Act provided for the establishment of the Commission for the Regulation of Electricity and Gas ('CREG'). It operates as an independent authority under the supervision of a governing board made up of representatives from the federal and regional governments, trade unions, organizations representing employers, distribution and consumer associations. Basically, the CREG is charged with monitoring and controlling the application of the Gas Act.

Belgium does not dispose of any natural gas reserves or natural gas production installations or facilities. In 2003, 691,466 TJ of natural gas was imported in Belgium, mainly from Algeria (LNG), Norway and The Netherlands. To this end, Distrigas NV has concluded long-term take-or-pay agreements with Sonatrach, Gasunie and GFU. The Slochteren contract was signed in 1965. It was agreed to extend supplies of the Dutch low caloric value gas until 2011. The Norwegian Ecofisk, Statfjord and Troll-Sleipner agreements for the supply of high caloric value gas were signed respectively in 1973, 1981 and 1986. Supplies are currently to be extended to 2011, 2010 and 2018, respectively. The contract for the supply of high caloric value LNG with Sonatrach was signed in 1976 and was extended to 2006. Smaller contracts - mainly to compensate for Algerian failures to supply the quantities contractually agreed upon - have been signed. The total regasification capacity of the Fluxys LNG terminal in Zeebrugge (currently 4.5 billion m^3) will be doubled by 2007. The capacity enhancement project requires the construction of a fourth storage tank and additional send-out capacity.

According to its own information, Fluxys transports annually some 16 billion m^3 of natural gas for redelivery to end-users in Belgium. Reserved long-term capacity on the primary market for border-toborder transit flows amounts to some 48 billion m^3 per year. There are two storage facilities in Belgium, both operated by **Fluxys.** The services are offered from the Loenhout underground storage facility and the Zeebrugge peak shaving facility. Loenhout has a storage capacity of 580 million m^3, whereas Zeebrugge has a capacity of 55 million m^3. The storage is filled by transporting LNG by truck from the Zeebrugge LNG terminal. The Zeebrugge Hub is operated by Huberator NV (Fluxys NV). In 2004 the daily average of the net trade volume on the Zeebrugge Hub was approximately 4,500 TJ. The daily average of physical volumes was approximately 1,000 TJ. 44 clients are trading on the Zeebrugge Hub. In 2004 Huberator, APX and Endex signed a cooperation agreement on developing an electronic natural gas exchange at the Zeebrugge Hub.

TRANSPORTATION:

The Belgian gas grid is connected to the United Kingdom through the Interconnector, owned by Interconnector UK Ltd. The Interconnector Zeebrugge Terminal is owned by Distrigas NV and Interconnector UK Ltd. The Zeepipe (owned by Gassled and operated by Gassco) connects the

Troll and Sleipner area's in the Norwegian North Sea to Zeebrugge. Gassled also owns the Zeepipe Terminal in Zeebrugge. Onshore, the vTn/rTr pipeline (linking Zeebrugge and Zelzate (Dutch border) or Raeren (German border)) and the Troll pipeline (linking Zeebrugge to the French border) are owned by Finpipe ESV, but operated by Fluxys NV. All capacity has been transferred to Distrigas & Co Comm. VA. The pipeline between The Netherlands and France is owned by Segeo NV. Etac BV commercialises the capacity on this pipeline, whereas Fluxys NV operates it. Lastly, the pipeline between Poppel (Dutch border) and Blaregnies (French border) transports low caloric natural gas and is owned and operated by Fluxys NV. Fluxys owns the storage facilities in Loenhout and the peak shaving installation in Zeebrugge.

LEGISLATION:

In accordance with article 20 of the Directive 2003/55/EC, the Gas Act stipulates that access to the upstream pipelines (Interconnector and Zeepipe) and the onshore terminals is regulated by **Royal Decree**, still to be enacted. Access to the storage facilities is regulated by the **Gas Act**, the Code of Conduct and the general terms and conditions of Fluxys. **Access to the transport pipelines is regulated by the same legislation.** In October 2006, Wingas GmbH received a transport licence for the construction and operation of a direct line linking the GTS-grid (The Netherlands) with BASF Antwerp.

THIRD PARTY ACCESS RIGHTS AND COST ALLOCATION:

Currently, access to the transit pipeline system is not regulated by the Gas Act (but only by an agreement between the Belgian State and Distrigas). Capacity has been commercialised by Distrigas & Co Comm. VA. In the modified Gas Act, access to the transit system will be treated in the same way as access to the transport system of Fluxys NV and will be operated (both technically and commercially) by Fluxys NV.

Access to the Fluxys transportation grid is subject to an RTPAsystem, whereby the tariffs and prices of Fluxys are to be approved by the **CREG** and then published. Access is subject to the acceptance of the Fluxys NV general terms and conditions, approved by the CREG in accordance with the Code of Conduct.

Belgian legislation provides that the following transport services are to be offered at regulated tariffs: capacity services; flexibility services; pressure reducing services; odorisation services; and quality conversion services. The regulated tariffs are cost-based. For that purpose the costs for Fluxys are divided over the various services that the company offers on the basis of objective criteria. Fluxys has to submit its budget and tariff proposal each year for the following year to the CREG. The competent minister can oblige Fluxys NV to carry out any connections or alterations he deems necessary, provided that the costs thereof are economically acceptable or carried by the customer. A connection tariff of €2,000 is applicable to establishing new legal and financial links between Fluxys and an end consumer on the grid. These tariffs do not cover costs related to field works to connect or to deconnect the end user.

TRANSMISSION AND DISTRIBUTION:

According to the organization of the Belgian federal state, the three Regions (Flanders, Brussels and Walloon) are the competent authorities for all matters with regard to the public distribution of natural gas. The federal state is competent for the transport and transmission of natural gas. Belgian legislation does not contain a clear definition of 'public gas distribution' or of 'transport of gas'. **The natural gas transmission network is owned and operated by Fluxys NV. The distribution networks are owned by intermunicipal associations or municipal companies.** Each intermunicipal association has a monopoly for the construction and operation of a natural gas distribution network in a certain geographical area.

In the three regions, the relevant legislation provides that a distribution network can only be operated upon the granting of a license by the competent ministers (Walloon region) or the regulator (Flemish region). In the Brussels region, only the existing inter-municipal association could be appointed as distribution system operator. In the three regions, the access to the natural gas distribution network is organized as a RTPA. The regulators can require a distributor to grant capacity or expand its system.

All three regions have adopted a RTPA-system. The tariffs and fees for the use of the distribution networks are regulated on a federal level by the federal legislator CREG. Due to historical reasons, the tariffs and fees are different for every single distribution grid operator.

COMPETITION:

With regard to competition policy and law, only the federal state is competent. The Belgian Competition Council enforces the provisions of the Belgian Competition Act in all sectors, including the natural gas sector. However, the Belgian Competition Council is not the sole body which applies the Belgian Competition Act. Belgian courts also apply the Belgian Competition Act, and the CREG takes Belgian competition law into account in its assessment. However, the Belgian Competition Council is the primary body enforcing Belgian competition law.

SINGAPORE

OVERVIEW OF NATURAL GAS SECTOR:

Singapore, having no known natural gas or crude oil reserves, meets its energy requirements by importing natural gas from Peninsula Malaysia and Indonesia. None of this imported gas is re-exported. The four offshore pipelines currently bringing natural gas into Singapore are:

Supplier / Source	Singapore Buyer	Quantity (mmscfd)
Petronas / Malaysia	Senoko Power	155
Petronas / Malaysia	Keppel Gas Pte Ltd	115
Pertamina / West Natuna, Indonesia	SembCorp Gas Pte Ltd	325
Pertamina / South Sumatra, Indonesia	Gas Supply Pte Ltd	350

The contract between Petronas and Senoko Power is due to expire in mid-2008 but is subject to renewal. A future supply of natural gas from South Sumatra has been secured and is due to commence flowing in 2009 to a new power station under development in Singapore by Island Power Pte Ltd, with an expected delivery volume of 100 mmscfd. The other three contracts have each come on-stream within the last six years, as the efficiencies of natural gas seek to replace the old diesel-fired stations. The piped natural gas is primarily utilized by the three main power generating companies - Tuas Power (2,670 MW), Senoko Power (3,300 MW) and PowerSeraya (3,100 MW) - which are presently Government-owned and jointly generate 90% of Singapore's power output. The remaining natural gas is used as feedstock for the production of town gas by

City Gas Pte Ltd, and a small portion is used by industrial users (although this is anticipated to increase as the capacity of Singapore's refineries increases). The vast majority of piped gas to Singapore's one million retail customers is town gas.

In March 2000, the Government announced its intention to **liberalize the gas market**. The key recommendations were - (a) separation of the contestable sectors, such as retailing, from the non-contestable sector of transportation; (b) a separate and independent gas transporter; (c) a single integrated gas network code; and (d) regulated open access to the integrated network, with contractually defined and tradable capacity rights within the transmission network. The Gas Act (Cap. 116A) ("**Gas Act**"), passed in 2001 to establish the regulatory framework for this liberalization, seeks to create a competitive market framework for the gas industry, and to provide for the safety, technical and economic regulation of the transportation and retail of gas in Singapore. Currently, only the competition provisions within the Gas Act are in force, but the remainder is expected be in force in 2007. **The Energy Market Authority** ("**EMA**") is both the gas and electricity regulator for Singapore, and is also responsible for overseeing the regulatory process. The Energy Market Authority (EMA) promotes competition in the electricity and piped gas industry and maintains the security and reliability of the power system. Formed on 1st April 2001, EMA is a statutory board under the Ministry of Trade and Industry that regulates the electricity and gas industry and district cooling services in designated areas.

It is intended that PowerGas Limited ("**PowerGas**"), a wholly owned subsidiary of Singapore Power Limited, will own the onshore gas pipeline infrastructure. This high pressure pipeline network is not currently integrated and a section of that network is owned by SembCorp Gas Pte Ltd ("**SembGas**"). In order to achieve the objective of liberalization, it is intended that the pipelines owned by SembGas will be divested to PowerGas and the network will be fully integrated. The distribution network is largely used for the conveyance of town gas although it has been mooted that the distribution network will in time be converted to natural gas. There are currently a small number of industrial users taking natural gas from parts of the distribution network.

There are no natural gas storage facilities in Singapore. The generating companies are required to maintain a minimum quantity of diesel as back-up in the event of a disruption to the supply of

natural gas. Singapore as yet does not have LNG receiving/re-gasification facilities. However, subsequent to an 18-month feasibility study commissioned by the EMA, the Government gave the go-ahead in August 2006 for the development of a 3 mtpa LNG terminal scheduled for completion between 2012 and 2014. To build up demand for LNG, a moratorium on the importation of piped natural gas is to be imposed in the lead-up to the terminal commissioning. The nascent gas market in Singapore is, therefore, in a period of transition while the regulatory framework remains to be settled.

TRANSPORTATION:

There are currently four separate pipeline networks bringing natural gas to Singapore as mentioned above - two from Malaysia and two from Indonesia. The ownership of those pipelines within the relevant territorial waters is as follows:

Pipeline	Export country	Singapore
Malaysia to Singapore 1	Malaysia (Petronas)	Senoko Power
West Natuna to Singapore	Indonesia (PGN)	SembGas
South Sumatra to Singapore	Indonesia (PGN)	PowerGas
Malaysia to Singapore 2	Malaysia (Petronas)	Keppel Gas (to be transferred to PowerGas)

For those contracts where the importer also owns the offshore pipeline, the importer takes title to the natural gas at the boundary line. For the importation of South Sumatra gas, PowerGas, as pipeline owner, has entered into a transportation agreement with GSPL to convey the natural gas from the boundary line to the point of injection within the onshore network. Although it was debated, the offshore pipelines in Singapore territorial waters will not fall within the ambit of the Network Code once it is implemented. To avoid concerns relating to third parties accessing the offshore pipelines, the EMA has recently proposed changes to the Gas Act requiring owners of such pipelines to make available capacity in their pipelines to third parties on a nondiscriminatory basis. The proposed legislation includes power given to the EMA to impose

allocation arrangements on users of such pipelines. It is anticipated that Parliament will enact the proposed changes to the Gas Act in early 2007.

TRANSMISSION AND DISTRIBUTION:

Currently, there are two gas networks in Singapore - the town gas network and the natural gas network. The town gas distribution network serves about half of the households in Singapore. Town gas, which is used mainly for cooking and water heating by domestic and commercial customers is produced and retailed by City Gas Pte Ltd using natural gas as the feedstock. It was originally intended to convert the town gas network to natural gas as part of the market liberalization process. This is no longer a prime objective, but it might re-appear on the agenda in the future. The onshore network conveying natural gas in Singapore is currently separated into three networks. In order to meet the objectives of market liberalization, it is anticipated that the networks will become interconnected. The Network Code distinguishes between high pressure gas pipelines with definable capacity rights (the "**Transmission Network**") and low pressure pipelines feeding retail customers (the "**Distribution Network**"). There are various points on the system where the natural gas is stepped down from the Transmission Network to the Distribution Network. Currently, there are less than 100 entities (mainly small industrial users) taking natural gas from what will be termed a Distribution Network. It is envisaged that both networks will be owned and operated by PowerGas in accordance with the Network Code. Persons wishing to convey natural gas through those networks will be termed "Shippers" and, if conveying gas through the Distribution Network, will be required to hold a retailer's license.

FEES FOR ACCESSING THE DISTRIBUTION NETWORK:

Distribution charges payable by retailers to Power Gas, as the gas transporter under the Network Code, will be based on usage. Together with the capacity charges required to reserve capacity to its relevant Transmission/Distribution Point, these fees are regulated by the EMA pursuant to the gas transporter's license.

COMPETITION:

The EMA regulates competition, or anti-competitive practices, via the Gas Act. There are two provisions governing competition in the Gas Act. Section 69 prohibits "agreements, decisions or concerted practices by persons which have as their object or effect the prevention, restriction or

distortion of competition in any gas market in Singapore", and any such agreement or decision shall be void. However, this prohibition only applies if the agreement decision or practice is, or is intended to be, implemented in Singapore. On the other hand, section 70 prohibits any conduct on the part of one or more persons which amounts to the abuse of a dominant position, within Singapore, in the Singapore gas market, if it may affect trade within Singapore. Notwithstanding the above, the EMA may grant an exemption from sections 69 or 70 to any such agreement or conduct. It also bears noting that the wording of sections 69 and 70 are almost identical to the corresponding provisions in the Competition Act (Cap. 50B).

UAE

OVERVIEW OF NATURAL GAS SECTOR

The UAE's natural gas reserves of 212 trillion cubic feet (tcf) are the world's fifth largest after Russia, Iran, Qatar, and Saudi Arabia. The largest reserves of 196.1 tcf are located in the Emirate of Abu Dhabi (onshore and offshore). The Emirates of Sharjah, Dubai, and Ras Al Khaimah contain smaller reserves of 10.7 tcf, 4.1 tcf, and 1.2 tcf, respectively. In Abu Dhabi, the non-associated Khuff natural gas reservoirs beneath the Umm Shaif and Abu Al Bukhush oil fields rank among the world's largest. Current natural gas reserves are projected to last for a further 150-170 years. The majority of UAE gas production is associated gas, and is utilized for a variety of purposes, including re-injection for oil reservoir pressure maintenance and industrial feedstock (particularly in the power generation and water desalination sector). A major new project - the Dolphin Project - aims to bring approximately 3 billion cubic feet per day (bcf/d) of natural gas from the North Field, offshore Qatar to the Sultanate of Oman and the UAE, with delivery points in the Emirates of Dubai and Abu Dhabi. First gas from the Dolphin Project is due for delivery in 2007. Abu Dhabi's master plan also calls for dramatic expansion of gas, particularly sour gas production; with an additional production capacity of 3 bcf/d added by 2001, to be utilized for a mixture of power generation and enhanced oil recovery.

TRANSPORTATION:

Each Emirate in the UAE owns and controls its own transportation pipelines and associated infrastructure. There are currently no public government initiatives regarding the ownership, organization and regulation of transportation pipelines and associated infrastructure. Various authorizations are required to construct and operate natural gas transportation pipelines and

associated infrastructure, including that of the Ministry of Petroleum (at a Federal level) and of the Ruler of the Emirate in question, together with Emirate specific additional approvals. The land in each Emirate is the property of the Ruler of that Emirate. Thus, the construction of any transportation pipelines or associated infrastructure requires a grant of the use of the land from the Ruler and also the consent of any private occupier of the land. The Ruler of each Emirate has the power of compulsory acquisition to facilitate land access.

There are no specific laws governing access to natural gas transportation pipelines and associated infrastructure. Given that the ultimate ownership of the land in each Emirate is in the hands of the Ruler, a right to construct any pipeline or associated infrastructure will include the right of access. There is no regulation concerning the integration or interconnection between different transportation systems. The interconnection of natural gas grids within the Emirates and between Qatar, the UAE and Oman are effected by negotiation and contract between the relevant parties.

THIRD PARTY ACCESS RIGHTS:

Because the provision and transport of natural gas is controlled by the Government of each Emirate and because there is no regulator, there is no question of a new customer compelling the operator /owner of a natural gas transportation pipeline or associated infrastructure to grant capacity or expand its facilities in order to accommodate the new customer. The parties are free to agree the terms upon which the natural gas is to be transported but all the parties involved are government owned or government controlled.

TRANSMISSION AND DISTRIBUTION:

There is no statutory framework for the ownership, organization and regulation of the natural gas transmission / distribution network in the UAE. Each Emirate is free to make its own arrangements regarding transmission/distribution. There are no public current major initiatives or policies of the government relating to natural gas distribution. Various authorizations are required to operate a distribution network including that of the Ministry of Petroleum (at a Federal level) and of the Ruler of the Emirate in question, together with Emirate specific additional approvals. There are no specific laws governing access to the natural gas distribution network. Given that the ultimate ownership of the land in each Emirate is in the hands of the Ruler, a right to construct any pipeline or associate infrastructure will include the right of access.

There is no regulator in the UAE. There is no regulation regarding fees for accessing the distribution network. Any such fees are a matter for negotiation between the parties. There is a general requirement that any legal entity in the UAE is majority UAE owned. Other than that there are no specific restrictions or limitations in relation to acquiring an interest in a gas utility, or the transfer of assets forming part of the distribution network.

COMPETITION:

Because of the Government ownership or control of the entities involved, there is no competition in the natural gas sector in the UAE.

EGYPT

OVERVIEW OF NATURAL GAS MARKET

Natural gas plays a vital role in the Egyptian energy sector and in achieving the nation's economic and environmental role. In 2006, natural gas production reached 38.4 million tcf. According to the Ministry of Petroleum official magazine, publication 10/43, October 2006 (Petroleum Magazine), natural domestic consumption of gas in Egypt was 79% of all production in 2006. In addition, there were 20 discoveries reported in 2006. These recent discoveries propelled Egypt to have a reserve estimated to be 68.2 billion tcf in July 2006. During the last five years, 73 oil and gas exploration and drilling agreements have been signed with international corporations and the Egyptian private sector (The Petroleum Magazine, p.17, p.43 and p.11). The development of tankers, which transport the gas in liquefied form (LNG), have led to major expansion in the gas export sector, decreasing transportation and project infrastructure costs. Currently, Egypt is ranked as the seventh largest exporter of LNG (as per the American Chamber of Commerce). Moreover, Egypt has entered into agreements with neighbors in the region to build gas pipelines to facilitate the distribution of gas outside Egypt.

TRANSPORTATION:

The concessionaire is responsible for constructing pipelines from the development area to the nearest access point in the national grid, or to an export point. Transportation pipelines and associated infrastructures in the national grid are executed by companies owned by the petroleum sector. Mainly, the Petroleum Pipelines Company promulgated by the Decision of the General

Institution for Petroleum No. 2 and other licensed companies are responsible for the extension of the pipelines and its accessories, the maintenance and operation thereof and for carrying out all activities relating to the purchase of the petroleum substance and its derivatives (Art. 2 of Decree 74/1968). The construction of pipelines is regulated by Law 4/1988 concerning Petroleum Pipelines (Law 4/1988) and its executive regulations issued by the Decree of the Minister of Petroleum 292/1988.All pipeline systems are installed and operated by PPC or other companies licensed and supervised by EGAS. They regulate the co-operation and overlap between them by reference to EGAS. Any plans for expansion of pipelines are laid down by EGPC within defined geographical areas and are carried out under its supervision. Third parties cannot force a pipeline or a storage facility operator to expand their facilities in order to accommodate them. The terms upon which natural gas is transported are regulated by EGAS and EGPC.

TRANSMISSION AND DISTRIBUTION:

The natural gas transmission/distribution network is governed by Law 217/1980 concerning Natural Gas and its executive regulations issued by the Decree of the Minister of Petroleum 820/1996. Law 217/1980 and Decree 820/1996, promulgated by Decision of the Ministry of Industry, Petroleum and Minerals 118/1978 (Decree 820/1996), delegate the Petroleum Gases Company to carry out such activities (Art. 1 of Decree 820/1996). EGAS may, in collaboration with or by delegation to other companies from the petroleum sector or companies incorporated under Egyptian Law, carry out the above activities as well (Art. 2 of Decree 820/1996). Currently, many companies are operating gas distribution for the local market, such as GASCO, a public company, and City Gas, a private company.

TO OPERATE DISTRIBUTION NETWORK:

Under Art. 2(2) of Decree 820/1996, EGPC's (and, in practice, also EGAS's) board of directors authorises companies to carry out activities related to gas distribution. In addition, it determines which companies work on the installation, modification, repair or maintenance of gas pipelines within residential areas or establishments, as well as power and gas stations and any other establishments that are authorized to receive natural gas (Art. 10 of Decree 820/1996). The boards of directors of EGPC and EGAS regulate gas distribution networks by setting out the specifications of and the qualifications required in companies that shall carry out or operate such networks. These specifications and qualifications are not disclosed.

5.3 REGULATORY FRAMEWORK OF MATURED GAS MARKETS

The matured gas markets include the following countries like:

- United Kingdom (UK)
- United States of America (USA)
- Australia

The gas regulations with respect to transmission and distribution of the matured gas markets are discussed below.

UNITED KINGDOM

OFGEM:

Office of gas and electricity markets is governed by an Authority, consisting of non-executive and executive members and a non-executive chair. Non-executive members bring experience and expertise, from a range of areas including industry, social policy environmental work, finance and Europe. The Executive members of the Authority are Ofgem's Chief Executive and three Managing Directors. The Authority determines strategy, takes all major decisions and sets policy priorities. The Authority's powers are provided for under the **Gas Act 1986, the Electricity Act 1989, the Utilities Act 2000, the Competition Act 1998 and the Enterprise Act 2002.** Protecting consumers is Ofgem's first priority. They protect it by,

- Promoting competition, wherever appropriate, and
- Regulating the monopoly companies which run the gas and electricity networks.

TRANSMISSION AND DISTRIBUTION:

Outlook:

Natural gas production is piped ashore to "beach" processing terminals. From the beach terminals (and the LNG terminals), processed natural gas will then usually be piped into the National Transmission System. The National Transmission System is effectively the high-pressure component of the United Kingdom's gas distribution network, and consists of 6,000 kilometers of pipelines and 23 strategically located compressors. The National Transmission System is owned and operated by National Grid which transports natural gas to power stations, large-scale industrial users and over 140 off-take points for distribution in 12 distinct Local

Distribution Zones ("LDZs") within the United Kingdom. The 12 LDZs are managed within eight geographical distribution networks.

The statutory framework applying in respect of the gas distribution network in the United Kingdom is set out in the Gas Act 1986. The foundation of gas distribution regulation in the UK is a system of licensing which seeks to distinguish between transporters, shippers and suppliers of natural gas. The Secretary of State has overall responsibility in respect of the gas distribution network, while day-to-day regulation has been delegated to OFGEM.

The three types of licenses applying in relation to the gas distribution network in the United Kingdom are:

1. **Gas Transporter's license**: this license authorizes the licensee ("Gas Transporter") to convey gas through pipelines to any premises within an area specified by the license held by the Gas Transporter, or to pipelines operated by another Gas Transporter
2. **Gas Shipper's License** - this license authorizes the licensee ("Gas Shipper") to arrange with a Gas Transporter for gas to be introduced into, conveyed by means of, or taken out of a pipeline system operated by that Gas Transporter.
3. **Gas Supplier's License** - this license authorizes the licensee ("Gas Supplier") to supply to any domestic or non-domestic premises gas which has been conveyed to those premises gas through pipelines.

License applications are made to OFGEM. The licenses contain standard conditions which are issued by the Secretary of State, but OFGEM is authorized to amend or modify these conditions as appropriate.

CAPACITY EXPANSION:

In relation to pipelines operated by Gas Transporters, an application can be made to OFGEM under the Gas Act 1986 for the increase in capacity of such pipelines through modification of associated works and apparatus, or for the installation into any such pipeline of a junction for connection of another pipeline. The applicant will, upon the granting of such an order, be obliged to provide such reasonable remuneration to the Gas Transporter as determined by OFGEM.

TARIFF:

In Britain, the regulator sets a cap on the average revenue Transco is allowed to earn similarly based on cost and what is deemed a reasonable rate of return on assets. The price cap is set for periods of five years. Annual reductions in allowable average revenue are determined by an efficiency (x) factor to provide an ongoing incentive for Transco to reduce its costs to protect its earnings. Gas Transporters charge connection and system-use charges, derived in relation to price control formulae and subject to price control by OFGEM, dictating the maximum revenue National Grid can earn for each unit of gas transported through its network.

COMPETITION:

The Office of Fair Trading ("OFT") is responsible for enforcing competition law in the UK. The Director General of Fair Trading ("DGFT") has responsibility under the Competition Act 1998, Articles 81 and 82 of the EC Treaty and the Fair Trading Act 1973 to investigate allegations of anti-competitive agreements and abuses of dominant market positions. In the gas sector, the DGFT has concluded a concordat with OFGEM, and the bodies will together regulate competition in the relevant markets, the continuing ability of licensee(s) to fulfill their duties under gas legislation, and the ability of the regulator to fulfill its own duties.

USA

FERC:

The Federal Energy Regulatory Commission is an **independent regulatory agency** charged with the regulation of certain aspects of the energy industry in the United States, including the regulation of natural gas transportation. It was created in 1977 under the Department of Energy Organization Act. Although a government agency, FERC is designed to be independent from any undue political party influence or affiliation, as well as independent from any influence from the executive or legislative branches of government, and industry participants, including the energy companies over which it has oversight.

REGULATORY FRAMEWORK:

Under the current regulatory environment, only pipelines and local distribution companies (LDCs) are directly regulated with respect to the services they provide. Natural gas producers and marketers are not directly regulated. This is not to say that there are no rules governing their

conduct, but instead there is no government agency charged with the direct oversight of their day to day business. Production and marketing companies must still operate within the confines of the law; for instance, producers are required to obtain the proper authorization and permitting before beginning to drill, particularly on federally-owned land. However the prices they charged are a function of competitive markets, and are no longer regulated by the government. Interstate pipeline companies, on the other hand, are regulated in the rates they charge, the access they offer to their pipelines, and the sitting and construction of new pipelines. Similarly, local distribution companies are regulated by state utility commissions, which oversee their rates, construction issues, and ensure proper procedure exists for maintaining adequate supply to their customers

TRANSMISSION AND DISTRIBUTION:

- Transmission pipelines are owned and operated by many different companies. The safety of construction, operation and maintenance of transmission pipeline systems is regulated by the Office of Pipeline Safety under 49 CFR Parts 192 and 195. The Federal Energy Regulatory Commission (FERC) regulates the transmission and sale of natural gas for resale in interstate commerce, and regulates the transmission of oil by pipeline in interstate commerce. FERC also approves the siting of, and abandonment of, interstate natural gas facilities, including pipelines, storage and liquefied natural gas (LNG). FERC does not regulate or provide oversight for the construction of oil pipelines; it does not regulate pipeline safety; nor does it regulate pipeline transportation on or across the Outer Continental Shelf.
- The distribution of natural gas in the United States is treated as a local function, and is subject to the laws and regulations of the states and localities in which particular natural gas retailers operate. That regulation typically will encompass the rates that may be charged to various classes of retail customers (such as residential, small commercial, industrial, etc.), their relative priority in case of necessary curtailment of service, and other critical terms and conditions of service.
- The individual authorisations required are established on a state-by-state basis and therefore will vary among the states.

- The rates and terms under which distributors must offer service over their systems are established on a state-by-state basis and will vary among the states.

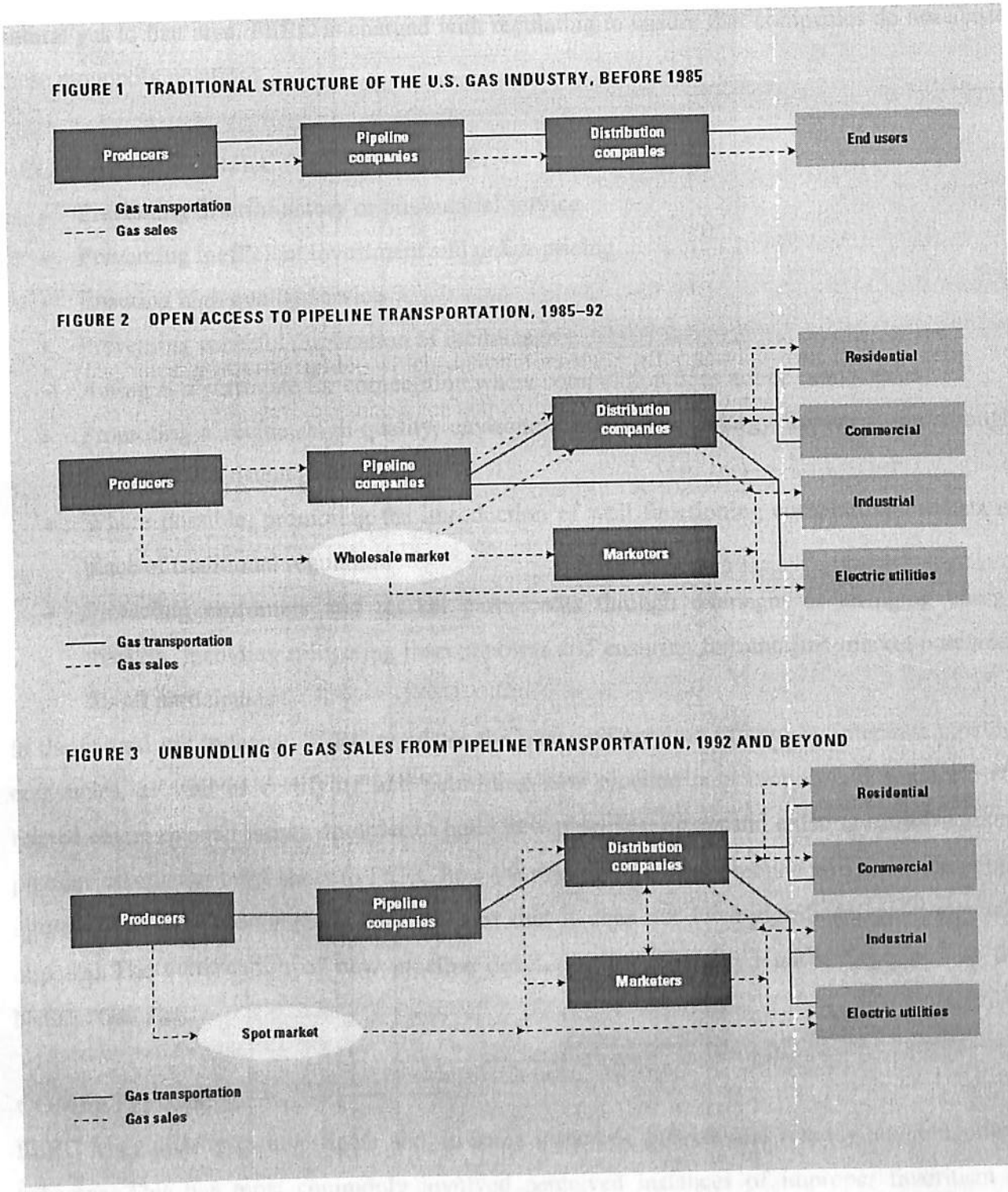


Fig 5.2 Evolution of USA Natural Gas Market

FERC oversees those industries in which member companies have significant market power over their sectors; for example natural gas pipelines are considered 'natural monopolies' due to the fact that in many areas, a single pipeline infrastructure has control over all of the transportation of natural gas to that area. FERC is charged with regulating to ensure that companies do not abuse these monopoly positions.

REGULATORY OBJECTIVES INCLUDE:

- Preventing discriminatory or preferential service
- Preventing inefficient investment and unfair pricing
- Ensuring high quality service
- Preventing wasteful duplication of facilities
- Acting as a surrogate for competition where competition does not or cannot exist
- Promoting a secure, high-quality, environmentally sound energy infrastructure through the use of consistent policies
- Where possible, promoting the introduction of well functioning competitive markets in place of traditional regulation
- Protecting customers and market participants through oversight of changing energy markets, including mitigating market power and ensuring fair and just market outcomes for all participants

In the natural gas industry, FERC regulates the rates and services offered by interstate pipeline companies, as well as certifying and permitting new pipeline construction and some closely related environmental issues. In order to build new pipelines, or expand existing infrastructures, pipeline companies must show to FERC how the new or expanded pipeline will serve the public interest, that it is economically feasible, and that it does not have significant environmental impacts. The certification of new pipeline developments is required under Section 7 of the Natural Gas Act.

COMPETITION:

FERC has authority to investigate and, in some instances, prevent and remedy anticompetitive behavior. This has most commonly involved perceived instances of improper favoritism of affiliates, whether in pricing of or access to services, or in the sharing of confidential third-party

information. FERC has promulgated detailed regulations, in the form of "standards of conduct," to define inappropriate behavior in this regard.

TARIFF STRUCTURE:

In North America, pipeline companies must seek approval from the regulatory authority (FERC in the United States; the NEB in Canada) for proposed rates. These proposals must be based on estimated annual operating costs plus a reasonable return on investment (cost-of-service). Rates are approved or modified on a case-by-case basis. In most cases, pipeline rates are required to be set using a straight-fixed variable methodology, whereby charges have to be broken down into a fixed capacity (or reservation) charge and a commodity charge (according to usage). Fixed costs must be allocated to capacity charges. As a result, 90% to 95% of pipeline revenue comes from capacity charges. FERC is considering allowing pipeline companies to negotiate rates where sufficient pipeline-to-pipeline competition exists. NEB is also considering alternatives to traditional cost-of-service regulations to provide incentives for pipeline companies to reduce costs and enhance the quality of service.

AUSTRALIA

The Australian Competition and Consumer Commission is an independent Commonwealth statutory authority. It was formed in 1995 to administer the *Trade Practices Act 1974* and other acts. The Australian Energy Regulator (AER) is a constituent part of the Australian Competition and Consumer Commission (ACCC). It was established under Part IIIAA of the Trade Practices Act 1974 and operates as a separate legal entity. The Australian Energy Regulator (AER) is to be the designated regulator for gas transmission pipelines in all states and territories (except WA) and for transmission and distribution pipelines in the Northern Territory.

The functions to be transferred to the AER are expected to include:

- Consideration and approval of access arrangements submitted by service providers under the National Third Party Access Code for Natural Gas Pipeline Systems. This process involves setting terms and conditions, including reference tariffs, which requires determination of a range of measures including asset valuation, a fair allocation of justified costs, a reasonable rate of return and an acceptable depreciation methodology.
- Monitoring and enforcing reference tariffs, ring-fencing, incentive regulation and other access arrangement provisions.

- Arbitrating disputes relating to the terms and conditions of access.
- Overseeing competitive tendering processes for new transmission pipelines.
- Contributing to the ongoing refinement of the national framework for access to transmission and distribution infrastructure in the gas industry.

The ACCC will continue to assess access undertakings and applications for authorization as these are instruments under the Trade Practices Act.

TRANSMISSION AND DISTRIBUTION:

The Australian States and Territories have jurisdiction in respect of natural gas transmission and distribution activities, and each State/Territory has enacted legislation to regulate these activities. The Governments issue licenses to approved entities to undertake these activities. There is a mix of both Government and privately owned transmission and distribution activities. Australian competition laws require transmission/distribution to be kept legally separate from gas trading businesses (whether wholesale or retail). Both transmission and distribution pipelines are subject to Australia's third party access regime. Regulation of the Australian natural gas market varies according to the respective market segment and jurisdiction. Transmission pipelines are regulated by the Australian Competition and Consumer Commission (ACCC). State authorities regulate the distribution and retail segments of the market. Regulations covering natural gas pipelines — both distribution and transmission — have a common source, with similar legislation being passed in each jurisdiction, the lead act being The Gas Pipelines Access (South Australia) Act 1997.

TARIFF STRUCTURE:

For pipelines covered by an access arrangement required under the Code, the access arrangement stipulates the tariffs the pipeline owner is entitled to charge for access to the pipeline. These tariffs are set by submission to the relevant regulator for gas transmission pipelines (ie the ACCC and for distribution pipelines is the competition regulator of the relevant State under State trade practices legislation). The pipeline owner and the prospective user are free to agree to vary the tariffs but, in practice, the pipeline owners generally insist on payment of the regulated tariffs. If a pipeline is not covered by an access arrangement, then the pipeline owner and prospective user are free to agree on tariffs for accessing the pipeline by way of private treaty.

COMPETITION:

In Australia, the Trade Practices Act 1974 (Cth) (TPA) regulates competition and consumer protection law. The objective of TPA is to enhance the welfare of Australians through the promotion of competition and fair trading and provision for consumer protection.

The Australian Competition and Consumer Competition (ACCC) is the body responsible for administering and enforcing the TPA. The TPA applies to the natural gas sector and the ACCC has had a very active role in gas market regulation.

CRITERIA FOR ANTI-COMPETITIVE BEHAVIOR:

In most cases, the ACCC determines whether a 'contract, arrangement or understanding has the purpose, effect or likely effect of substantially lessening competition' in the market place. Certain arrangements between actual or potential competitors, such as those to fix, maintain or control prices, market sharing, collective boycott arrangements, and arrangements to fix a minimum resale price are considered to be anti-competitive in their own right. It is possible to seek authorization of anti-competitive practices where a public benefit can be established.

ACTION AGAINST ANTI COMPETITION:

The ACCC has the power to impose significant penalties on market participants that have been found to engage in anti-competitive conduct. At present, the maximum penalty for a corporation in breach of the competition provisions in the TPA is A $ 10million. The Trade Practices Legislation Amendment Bill 2005 provides for amendments to be made to the TPA so that the maximum penalty for a corporation will be the greater of A $ 10million or three times the gain from the contravention or, where gain cannot be readily ascertained, 10% of the turnover of the corporation. Individuals can also incur penalties under the TPA. Further, the Australian Government has also announced that it is committed to introducing criminal penalties for serious cartel conduct to eliminate anti-competitive activity.

5.4 REGULATORY FRAMEWORK OF INDIAN GAS MARKET

OVERVIEW OF INDIAN NATURAL GAS INDUSTRY

Oil and Natural Gas Corporation Limited ('**ONGC**') and Oil India Limited ('**OIL**'), both public sector undertakings, were the only two major entities involved in exploration and production of Natural Gas till the 1990s. The Government allowed private participation in the mid 1990s and has also divested a part of its shareholding in ONGC to the general public. GAIL India Limited ('**GAIL**'), formerly known as Gas Authority of India Limited, was set up by the Government of India in 1984 to create infrastructure for sustained development of the gas market in the country. GAIL is the principal gas transmission and marketing company in India. GAIL owns around 4,600 km of pipeline out of the total of 6,500 km of pipeline in the country. OIL also has a marginal share in marketing of natural gas. Private participation in marketing and transmission of natural gas is also allowed. As per the information available the total proven reserves of natural gas in India in the year 2004 were approximately 930 billion cubic meters. Over 70% of the country's natural gas is produced offshore. Most of the natural gas reserves in India are found on the west coast. Significant discoveries of natural gas reserves have also been made on the eastern coast mostly around the Krishna-Godavari basin. In September 2005, ONGC announced discovery of around 3-6 trillion cubic feet ('**TCF**') of associated gas reserves in the Krishna-Godavari basin that is adjacent to Reliance Industries block, where 7 TCF of gas had been discovered. Onshore natural gas reserves were found in the States of Tripura, Assam, Arunachal Pradesh, Nagaland, Andhra Pradesh, Tamil Nadu, Gujarat and Rajasthan. However, indigenous production of natural gas is not sufficient to meet the growing demand for natural gas. A major part of the demand is met through imports of gas from countries rich in natural gas. There are proposals to import natural gas through pipelines from Iran, Myanmar, Bangladesh and Turkmenistan and necessary discussions with the concerned countries are underway. Natural gas is also imported in form of Liquefied Natural gas ('**LNG**') from Iran, Qatar etc. GAIL, ONGC, Indian Oil Corporation Limited ('**IOCL**') and Bharat Petroleum Corporation Limited ('**BPCL**') together promoted Petronet LNG Ltd. ('**PLL**') with an objective of securing LNG supply at a competitive price and for the development of regasification facilities in India. PLL has setup its first LNG Terminal at Dahej in the State of Gujarat with the capacity of 5 million metric tons per annum ('**MMTPA**') and is in the process of setting up another terminal in the State of Kochi in Kerala with the capacity of 2.5 MMTPA. In addition, private players have set up or are in the

process of setting up LNG import terminals and re-gasification units in India. Shell India Private Limited ('**Shell India**') has a 2.5 MMTPA capacity LNG terminal at Hazira in the State of Gujarat. Other LNG terminals under implementation/consideration are the Dabhol LNG Terminal by Dabhol Power, at Mangalore, Kakinada, Ennore and Trombay etc.

Fig 5.3 Natural Gas Market Existing

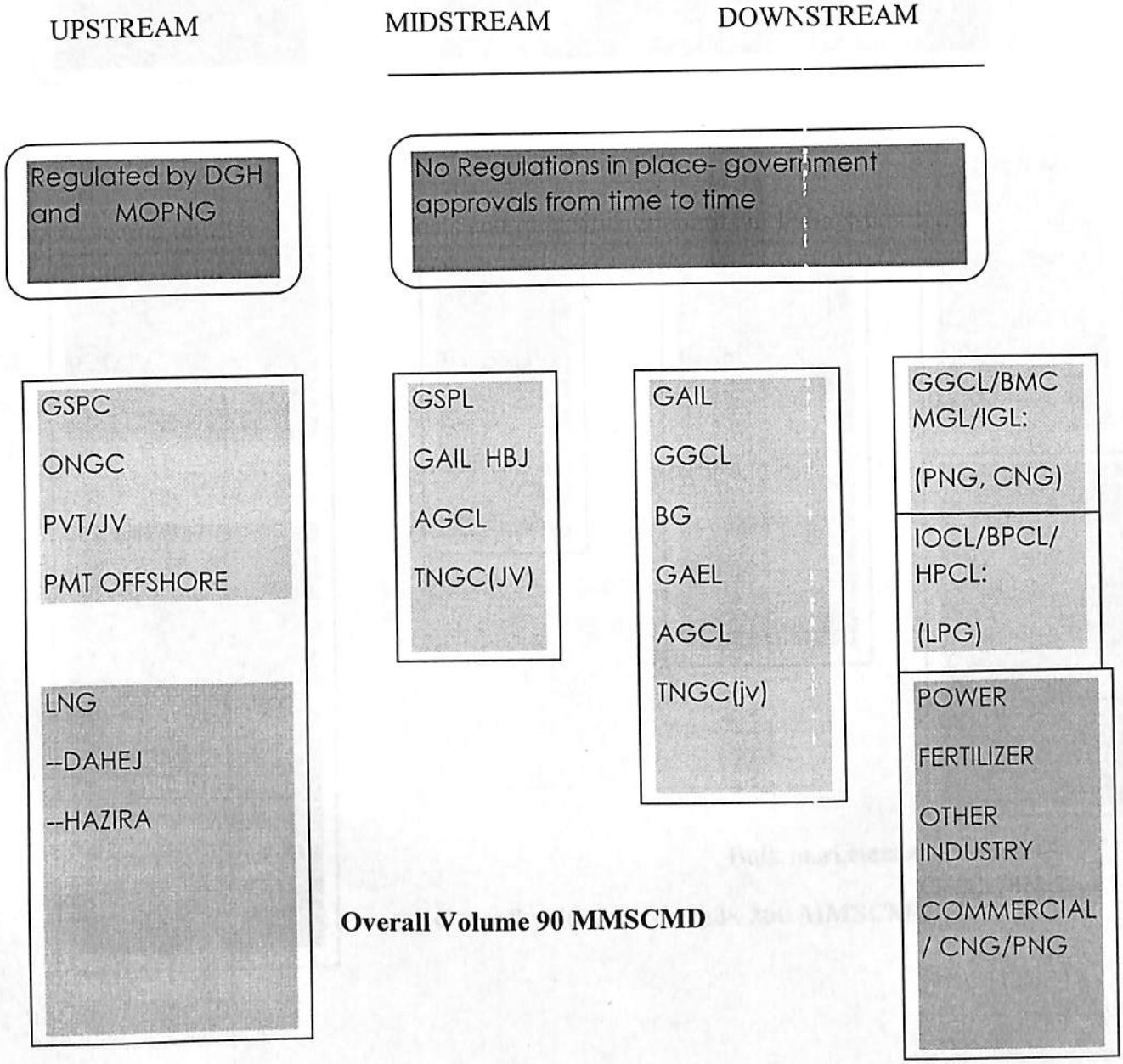
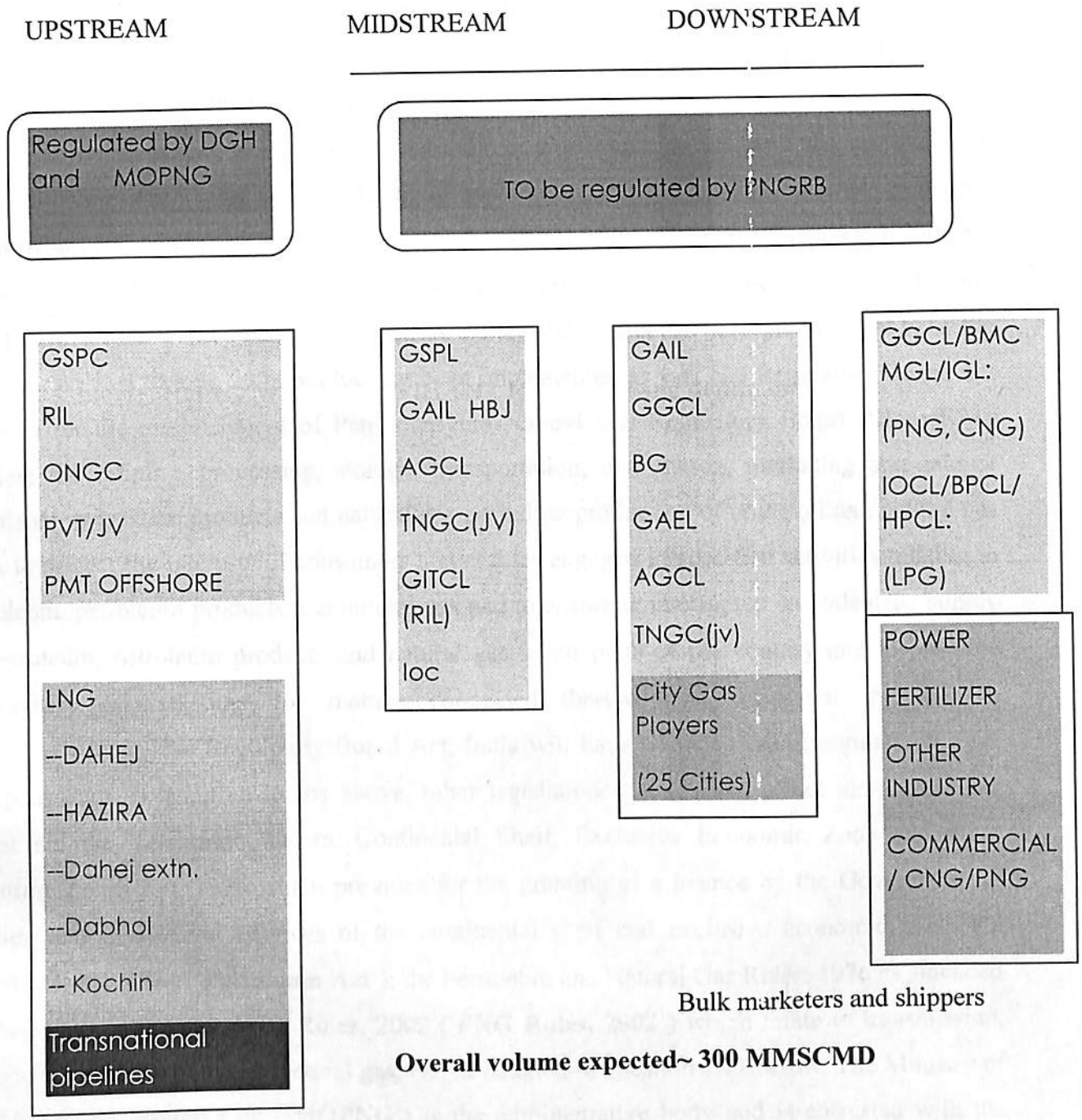


Fig 5.4 EMERGING MARKET STRUCTURE: Increasing depth and complexity



Overall volume expected~ 300 MMSCMD

5.4.1 DEVELOPMENT OF REGULATIONS IN INDIAN GAS MARKET

The legal/statutory framework for exploration and production of natural gas is mainly governed by The Oilfields (Regulations and Development) Act, 1948 ('**Oilfields Act**'); and The Petroleum and Natural Gas Rules, 1959 ('**PNG Rules**') framed under the provisions of the Oilfields Act. The Oilfields Act provides for regulation of oilfields (the definition of which covers gas fields) and for the development of mineral oil (the definition of which covers natural gas) resources. The PNG Rules, 1959 regulate the granting of exploration licences and mining leases in respect of petroleum and natural gas that belongs to Government, and for conservation and development thereof. A new legislation called the Petroleum & Natural Gas Regulatory Board Act, 2006 ('**Regulatory Board Act**') has been passed by the legislature and has been given assent to by the President on 31st March, 2006 but has not been implemented as yet. The Regulatory Board Act provides for the establishment of Petroleum and Natural Gas Regulatory Board ('**Board**') to regulate the refining, processing, storage, transportation, distribution, marketing and sale of petroleum, petroleum products and natural gas excluding production of crude oil and natural gas so as to protect the interests of consumers and entities engaged in specified activities relating to petroleum, petroleum products and natural gas and to ensure uninterrupted and adequate supply of petroleum, petroleum products and natural gas in all parts of the country and to promote competitive markets and for matters connected therewith or incidental thereto. On implementation of the Regulatory Board Act, India will have an independent regulator for gas and petroleum. In addition to the above, other legislations/statutes that affect the natural gas sector are the Territorial Waters, Continental Shelf, Exclusive Economic Zone and other Maritime Zones Act, 1976 which provides for the granting of a licence by the Government to explore and exploit the esources of the continental shelf and exclusive economic zone; the Petroleum Act, 1934 ('**Petroleum Act**'); the Petroleum and Natural Gas Rules, 1976 as amended by Petroleum and Natural gas Rules, 2002 ('**PNG Rules, 2002**') which relate to transmission, distribution and marketing of natural gas, etc. as detailed in question 2.11 below. The Ministry of Petroleum and Natural Gas ('**MOPNG**') is the administrative body and is entrusted with the responsibility related to exploration and production of oil and natural gas, their refining, distribution and marketing, import, export, and conservation of petroleum products and LNG. With a view to promote sound management of the Indian petroleum and natural gas resources having a balanced regard to the environment, safety, technological and economic aspects of the

petroleum activity, the MOPNG constituted the Directorate General of Hydrocarbons ('**DGH**'). DGH personnel have been appointed by MOPNG to serve as Chairman / Members / Alternate Members in various Management Committees of Discovered Fields & Exploration Blocks, on behalf of Government of India. The role of such personnel is to ensure optimum exploitation, to review/approve development plans, work programmes, budget, reservoir evaluation and to advise on midcourse corrections with regard to the discovered fields and appraisal of work programme and monitoring of exploration activities in relation to exploration blocks. The Government launched the New Exploration Licensing Policy ('**NELP**') in the year 1997 for accelerating the pace of hydrocarbon exploration in the country. Till now blocks have been allotted by the Government to the national oil companies and to private entities for exploration and production under five rounds of NELP and recently bids were invited for the sixth round of NELP. Under the NELP, the successful parties are required to enter into a production sharing contract with the Government. In addition, the Government frames policies for exploration, production, transmission, distribution, marketing of natural gas. Natural Gas Pipeline Policy and policy for import of LNG is in the process of finalization. The Natural Gas Pipeline Policy aims to develop pipeline infrastructure and standards for interconnectivity, common carriage, capacity for transmission and regulation of tariffs.

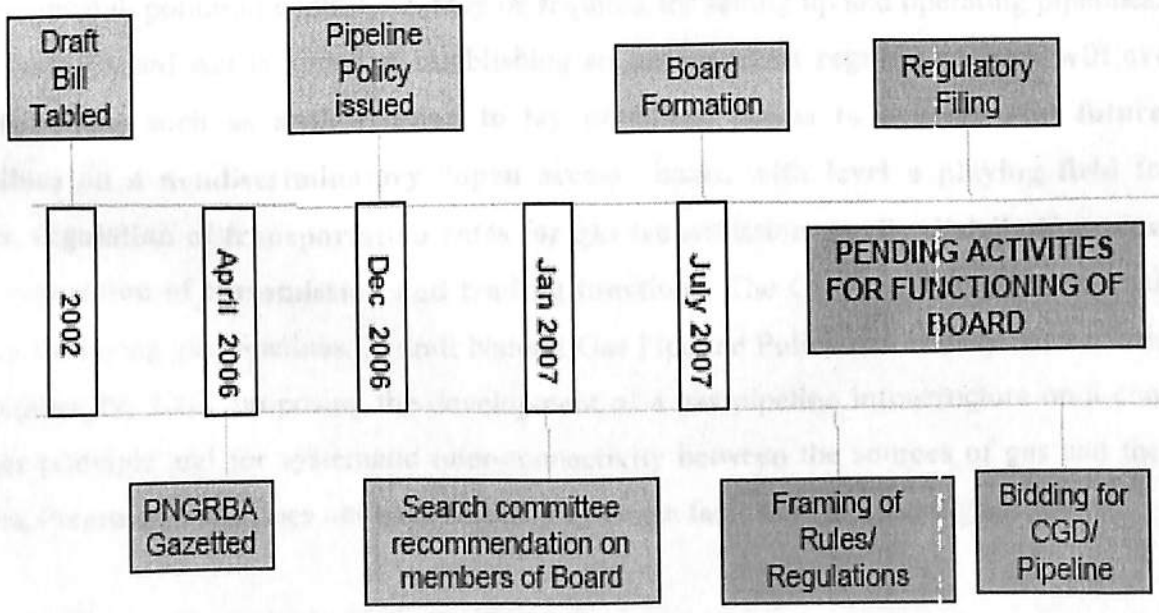


Fig 5.5 REGULATORY DEVELOPMENTS IN INDIAN GAS MARKET

TRANSPORTATION

The gas transmission and distribution network is largely owned by GAIL. The largest pipeline system in India is the HBJ (Hazira- Bijaipur-Jagdishpur) trunk pipeline system, which is more than 2,000 km long. In addition, there are regional gas grids of varying sizes in Gujarat (Cambay Basin), Andhra Pradesh (Krishna- Godavari Basin), Assam (Assam-Arakan Basin), Maharashtra (ex- Uran terminal), Rajasthan (Jaisalmer Basin), Tamil Nadu (Cauvery Basin), and Tripura (Arakan Basin). Natural gas for domestic purpose is also being supplied through pipelines in cities like Mumbai and Delhi. Construction of a "National Gas Grid" to connect gas supply points, from LNG as well as NELP fields with consuming centres, is one of the major priorities GAIL has unveiled, with plans for the construction of over 7,000 km of pipelines for a cost of about $4.5 billion by 2008. The Petroleum and Mining Pipeline (Acquisition of Right of Users in Land) Act, 1962 ("Pipeline Act") has provisions for acquisitions of right of way for laying transportation pipelines. The Pipeline Act requires obtaining prior approval from the Central Government before the actual construction and laying of the pipeline is undertaken. The acquisition of right of way under the Pipeline Act will be subject to conditions which may include the sharing of portions of acquired rights of way falling within the forest areas, wild-life / marine sanctuaries / parks, prohibited / restricted areas, etc. with other interested parties. In addition, other authorizations, clearances under the Forest (Conservation) Act, 1980 such as environmental, pollution control etc. may be required for setting up and operating pipelines. The Regulatory Board Act is aimed at establishing an **independent regulator which will oversee the functions such as authorisation to lay pipelines, access to existing and future gas pipelines on a nondiscriminatory "open access" basis, with level a playing field for all users, regulation of transportation rates for gas transmission or city distribution pipelines and separation of transmission and trading functions.** The Government will soon finalize a policy for laying gas pipelines. A draft Natural Gas Pipeline Policy has already been notified on September 29, 2003, proposing the development of a gas pipeline infrastructure on a common carrier principle and for systematic inter-connectivity between the sources of gas and the user points. Presently, India does not have any major storage facilities for natural gas.

TRANSMISSION AND DISTRIBUTION

GAIL is India's principal gas transmission, supply and distribution company. GAIL is the owner and operator of India's largest gas transmission network, which is around 4,600 km of pipeline.

ONGC is also a major player in the field of supply and distribution of natural gas. ONGC and GAIL are Government of India undertakings. There are some private players as well, such as Gujarat State Petroleum Limited in Gujarat, Mahanagar Gas Limited in Mumbai, Indraprastha Gas Limited in Delhi, etc. for transmission and distribution of natural gas. At present, there is no regulatory framework for the transmission of natural gas. The Regulatory Board Act, once implemented will regulate the transmission and distribution of Natural Gas.

Government authorization required to operate a distribution network As per the Regulatory Board Act authorization and registration is required to lay, build, operate or expand any pipeline as a common carrier or contract and to lay, build, operate or expand any city or local natural gas distribution network. An application in writing to the Board has to be made for obtaining authorizations under the said Act. The said Act has received Presidential Assent but is yet to be implemented. At present, there are no specific rules or regulations that govern operation and distribution networks

5.4.2 PETROLEUM & NATURAL GAS REGULATORY BOARD ACT – 2006

Broad Scope of the Regulator:

- **Transmission**: to authorize, regulate, register entities to lay, build, operate common carrier or contract carrier for gas transmission.
- **Distribution**: to authorize entities to build, operate or expand common carrier or local gas distribution networks.
- **Tariff:** to regulate transmission tariffs,
- **Access:** to regulate access to common contract carrier,
- **Terminals& Storage**: to register entities to establish LNG terminals & storage facilities.

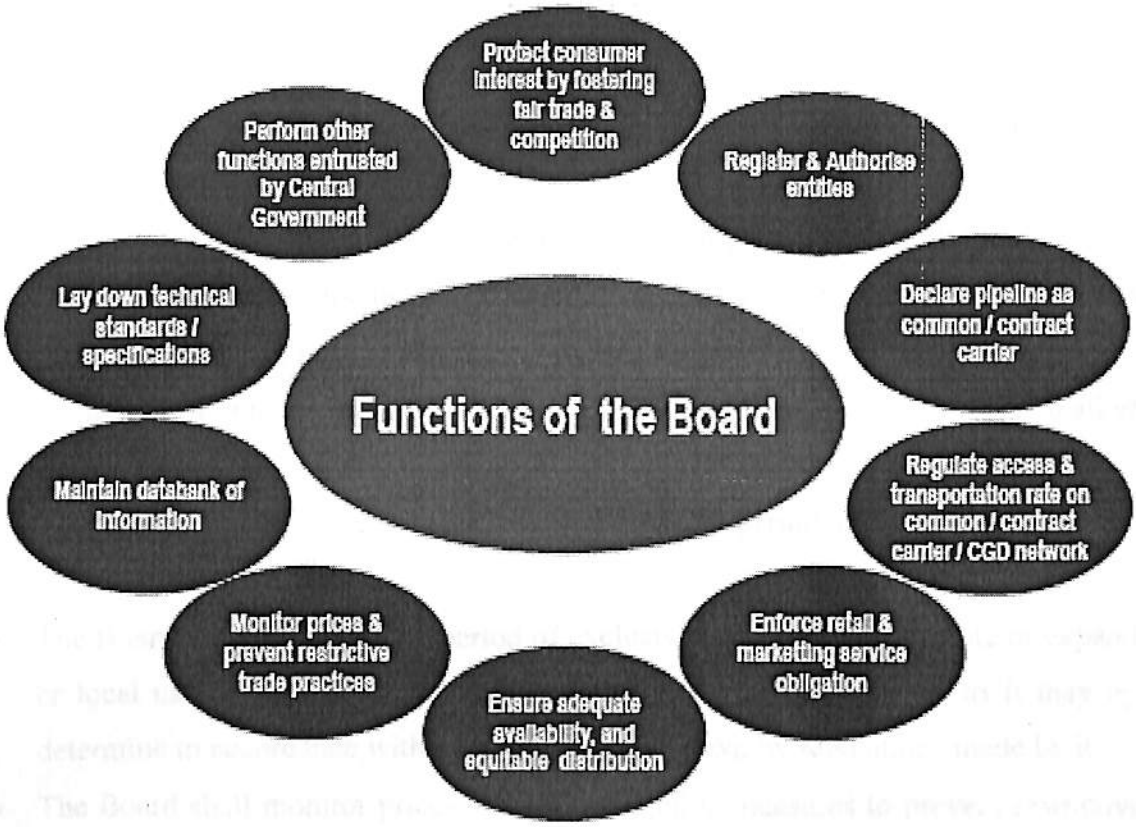


Fig 5.6 FUNCTIONS OF PNGRB

KEY CLAUSES OF PNGRB ACT, 2006:

- Entity laying, building, operating or expanding common carrier, contract carrier, CGD or local gas distribution network immediately before appointed date shall be deemed to have authorization
- The board may form an opinion that it is necessary or expedient to lay, build, operate or expand a common /contract carrier between two specified points either on
    - Basis of application or
    - Suo moto basis
- The Board may declare pipeline or network as a Common carrier with the objective of
    - Promoting competition among entities
    - Avoiding in fructuous investments
    - Maintaining or increasing supplies
    - Securing equitable distribution
    - Ensuring adequate availability

- Right of first use
    - The entity laying building operating or expanding a pipeline for transportation, CGD or local gas distribution network shall have the right of first use
- Affiliate Code of Conduct
    - Entity engaged in both marketing of natural gas and laying ,building operating or expanding a pipeline for transportation of natural gas on common/contract carrier would be required to comply with affiliate code of code
    - The regulator may require such entity to separate the activities of marketing of natural gas and the transportation including ownership of the pipeline
    - Right of first use will be valid only in the period wherein the entity is having bundled functions
- The Board may decide on the period of exclusivity to lay, build, operate or expand a city or local natural gas distribution network for such number of years as it may by order determine in accordance with the principles laid down by regulations made by it.
- The Board shall monitor prices and take corrective measures to prevent restrictive trade practices by the entities

5.4.3 DRAFT POLICY FOR DEVELOPMENT OF NATURAL GAS PIPELINE AND CGD NETWORKS

- **Infrastructure**
    - There is an imminent need to provide a policy framework for the future growth of the pipeline infrastructure to facilitate evolvement of a nation-wide gas grid and growth of city or local gas distribution networks
    - There is growing recognition that competition can reduce the need for regulation, in many areas
    - Natural gas pipelines infrastructure and city gas distribution networks are areas of monopoly where the benefits of regulation potentially outweigh the cost
- **Pipeline Capacity**
    - No gas pipeline or the city or local gas distribution network will be laid, built, operated or expanded without the authorization by the Board

- Provided that such an authorization for gas pipeline shall be granted to any entity only if the design pipeline capacity is at least 33% more than the capacity requirements of the concerned entity plus the firmed up contracted capacity (termed as total capacity).
- The extra capacity should be available for use on common carrier basis by any third party on open access and non- discriminatory basis at transportation rates laid down by the Board
- The capacity available under "open access" common carrier basis will be allocated on the principle of 'first come first serve' basis

- **Exclusivity**
  - The Board may decide on the period of exclusivity to lay, build, operate or expand a city or local natural gas distribution network in accordance with its regulations in a transparent manner while protecting the consumer interest.
  - The Board may consider different exclusivity periods for setting up of city gas distribution network and for marketing of gas by the entity developing such network.
  - The exclusivity period for marketing may be for a lesser duration as compared to that for setting up of the network, and may be considered below a predetermined volumetric threshold.
- **Cancellation of Authorization**
  - The Board will review the progress of projects periodically with the authorized entities to satisfy itself that the conditions of authorization and milestones given in the project report are being fully complied.
  - If the project is delayed beyond the stipulated period or the milestones and/or any other condition of authorization are not adhered to, the bond amount of the authorized entity may be forfeited and the authorization cancelled.
  - Once the authorization of the entity is cancelled, the Central Government may withdraw the ROU from such an entity and make the same available to any other entity authorized by the Board.
- **Unbundling**
  - In the long run and with the maturing of gas markets, it is envisaged that the authorized entities will have transportation of natural gas as their sole business

activity and will not have any business interests in the gas marketing or city or local gas distribution networks.

- The Board may intervene at an appropriate stage to ensure unbundling of transportation from other activities of the entities.

5.4.4 KEY ISSUES REQUIRING REGULATORY GUIDELINES

- Authorization
  - What would be the procedure for granting authorization if there are two or more entities interested in setting up a CGD network for a given geographical area?
- Open Access
  - What would be the terms for open access? How would the First come First Served principle be applied?
  - What if demand for the capacity exceeds the mandated 33% capacity?
  - Who would bear the cost of additional mandated 33% capacity to be made available on open access basis? How would such cost be recovered
- Exclusivity
- Marketing exclusivity
  - What should be the duration?
  - What should be the volumetric cut off?
- Distribution exclusivity
  - What should be the duration?
  - What should be the definition of service area?
- Tariff
  - What would be the allowable return?
  - How would the Regulatory Asset Base be valued?
  - What would be the allowable costs?
  - How would the regulator reward efficiency?
  - Would efficiency gains be clawed back or allowed to be retained by entities?
- Market Service Obligations

- What kind of marketing service obligations could the regulator enforce on companies engaged in marketing and distribution of natural gas and petroleum products?
- Test of economy?
- Safety and Technical issue?
- In fructuous investments?

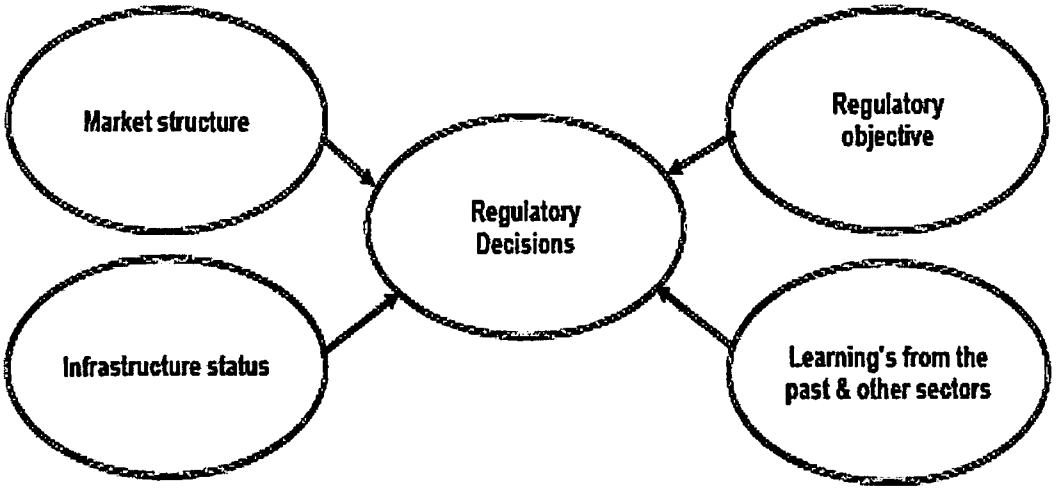


Fig 5.7 KEY DRIVERS FOR REGULATORY DECISIONS

5.4.5 ROLE OF CENTRAL GOVERNMENT IN REGULATIONS

- Petroleum and Natural Gas Regulatory Bill -2006, approved by Govt. and Regulatory Board setup.
- Ensure proper facilitation for market creation stage leading to market take off stage and further to market maturity stage.
- Clear cut policy framework & accelerated approval process for pipeline infrastructure creation.
- Ensure full autonomy to the regulatory Board while giving guidelines / approvals / authorization.
- To ensure formulation of codes / standards and making use of the standards mandatory for all CGD players.
- Need to formulate codes /regulatory framework to ensure relevant standards being adopted taking in to account the Indian context.

- Facilitate setting up of Technical institutes/collages offering specialized courses in gas engineering, training institutes offering certified courses.
- To develop framework for authorized autonomous institutions to certify contractors for undertaking the specific execution of specific jobs related to pipelines.
- The regions should ensure effective implementation of authorizations issued.

5.4.6 ROLE OF STATE GOVERNMENT IN REGULATIONS

- To work very closely with the central regulatory authority and regional offices of the regulator.
- To oversee safety aspects for operating city gas networks.
- To ensure proper planning of utility corridors in the city/towns, laying of gas networks at safe distances from the building & premises at all locations in congested cities / towns.
- Speedy permission/ approval process for laying of networks within cities/ Construction of CNG stations.
- .Adopting a proactive role of coordination with local municipal authorities & amongst all utilities to minimize damages.
- To ensure Continuous awareness creation amongst the customers/ general public about piped Natural Gas and Hazards through involvement of district administration.
- Issue of licenses to local contractors and their manpower for undertaking the gas installation related works in the customer premises to ensure consistency of output.

5.4.7 CHALLENGES FOR REGULATORY AUTHORITY

- To ensure fair pricing of the end of the chain at the same time adequate returns to the infrastructure creation players.
- To bundle most remunerative cities/towns with not so remunerative areas so that the infrastructure gets created on a similar time table basis in all areas.
- Need to have facilitative/ consultative approach with all the related industry players.
- How to ensure same price of CNG across a single state having multiple CGD players.
- Ensure protection of consumer interests.
- Ensure that CGD players meet the service obligations and levying strict penalties for non adherence.

5.5 COMPARISON OF INDIAN GAS MARKETS WITH DEVELOPED AND MATURED MARKETS

International Comparison:

Comparison of Regulatory design parameters				
Parameters	**India**	**UK**	**USA**	**AUS**
Midstream Industry structure	**?**	**Completely Unbundled**	**Unbundled**	**Unbundled**
Ownership	**Private partnership is allowed in approved pipelines**	**Private**	**Private**	**Private and Public**
Regulatory Body	**PNGRB**	**OFGEM**	**FERC**	**ACCC/AER**
Ownership	**Government body**	**Independent**	**Independent**	**Independent**
Pipeline Access Conditions	**To be decided by PNGRB**	**Contract Carrier**	**Common Carrier**	**C**
Transmission pipelines regulated by	**PNGRB**	**OFGEM**	**FERC**	**ACCC**
Distribution pipelines are regulated by	**PNGRB**	**OFGEM**	**STATE Commissions**	**STATE Commissions**

Table 5.1 COMPARISON OF INDIAN GAS MARKETS WITH OTHER MARKETS

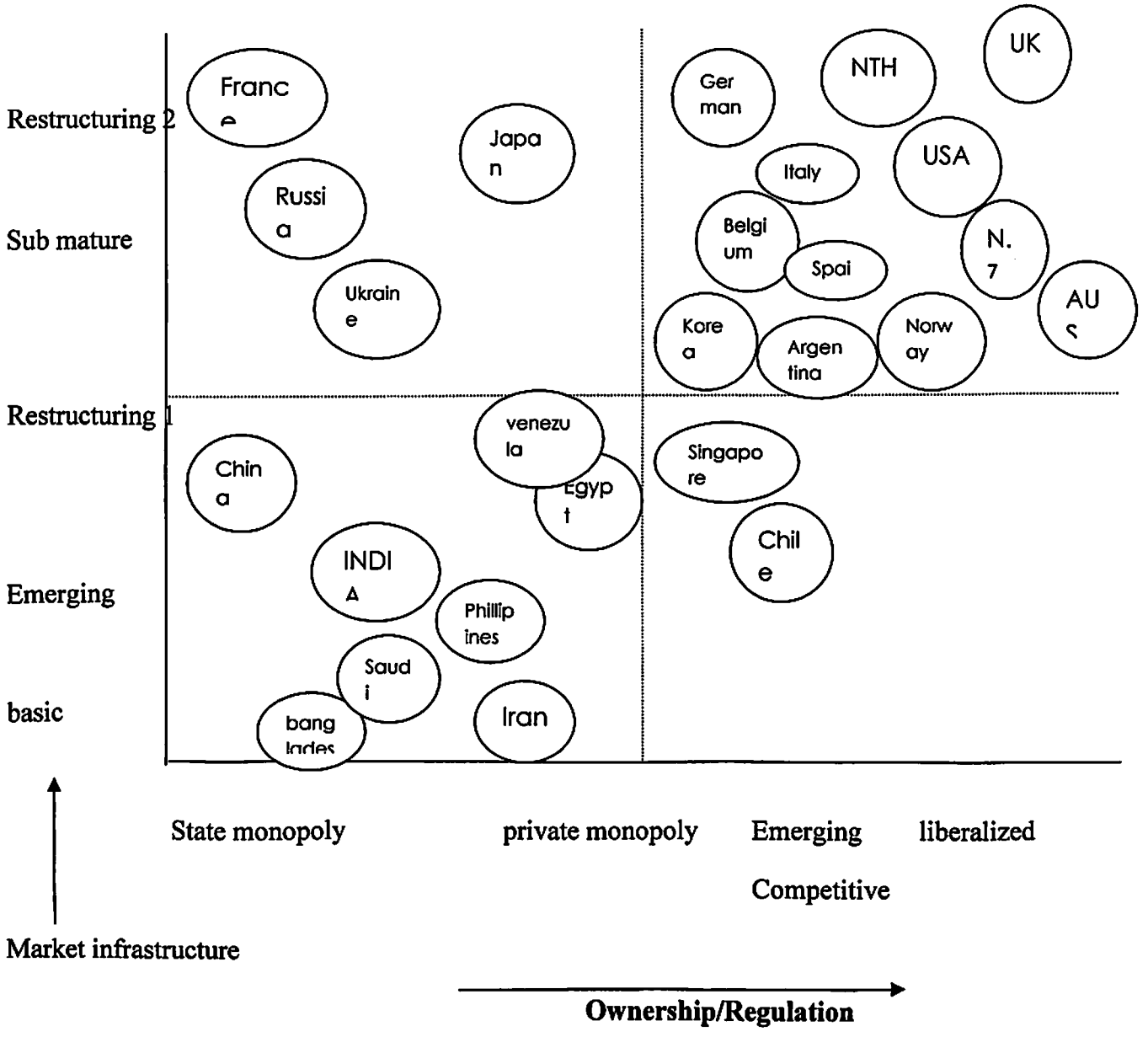


Fig 5.8 MARKET EVOLVUTION AS THEY MATURE

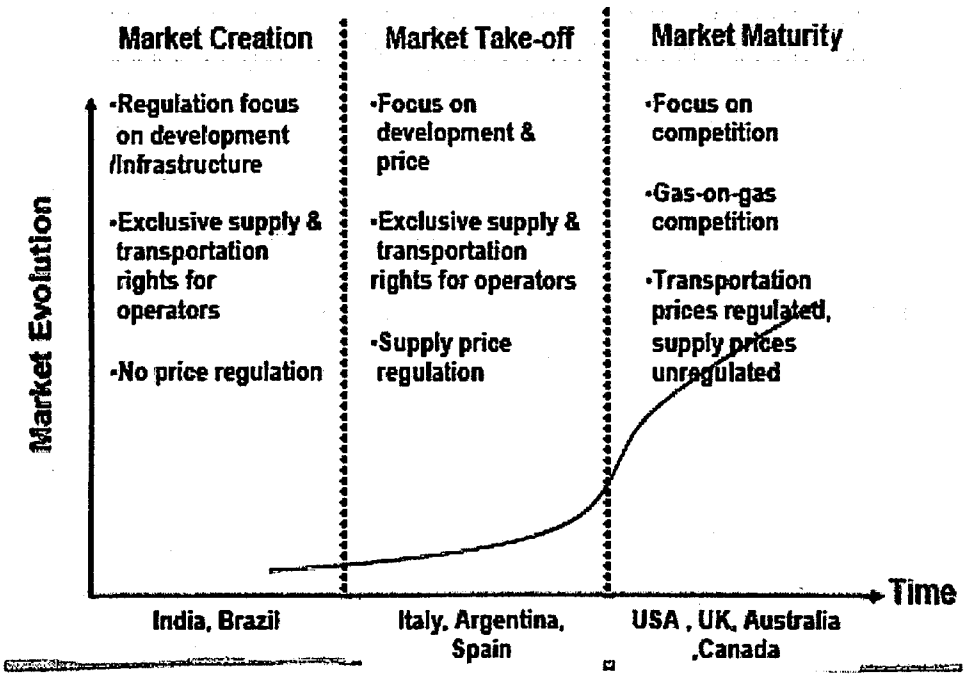


Fig 5.9 REGULATION LIFE CYCLE

5.6 SUGGESTIONS FOR INDIAN GAS MARKET REGULATORY FRAMEWORK:

- The rules for gas transmission, distribution, distribution and supply must be clearly established.
- Imminent Federal Regulation should:
  - Ensure an investment-encouraging framework for the nascent natural gas industry.
  - Clearly address third party access and right to build new pipelines.
  - Minimize regulatory risk for new investors.
  - Promote an interconnected gas grid.
- Regulation must evolve appropriately as the industry develops.
- Draft Interim Pipeline Policy should:
  - Include all existing, approved and new Inter-State pipelines.
  - Allow non-discriminatory, transparent, third party access to existing pipelines.
- Tariff Regulation should ensure efficient operation and development of capacity:
  - Best achieved through price control, rather than profit control.

- Cost plus approach does not provide adequate incentives to achieve efficiencies.

- Regulator must be independent, free of interference from Central and State Governments.
- Future Policy framework must decentralize regulatory regime, safeguard investors and consumers' interests.
- Presently India is in the market creation stage which is also called as Emerging market.
- For India to reach the Market take-off stage which is also called as Developed market the following steps have to be taken:
  - It should focus on development and price.
  - Exclusive supply & transportation rights should be given to the operators.
  - Supply price regulation should be implemented.
- For India to reach the Market maturity stage which is also called as Matured market the following steps have to be taken:
  - It should focus on competition.
  - Gas on gas competition should be present.
  - Transportation price regulation must be implemented and supply prices must be unregulated.
- For Indian Gas market to reach the matured gas market stage then the growth should be diagonally i.e. both the market infrastructure and Ownership / Regulation should increase.
- The market infrastructure should grow towards matured market infrastructure through Restructuring 1, sub mature and Restructuring 2 stages of market infrastructure.
- The ownership / regulation should increase towards the liberalized regulation through state monopoly, private monopoly and emerging competitive regulated markets.

CONCLUSION

We have seen all the benefits related to the use of gas. Gas is the fuel of the future. Gas is not only cost efficient and also energy efficient. So, using gas is not only saving customer's money but also saving energy for the country. All the commercial setups and Industries are focusing on gas for their fuel supply. Even if gas is priced by market driven forces it will be of competitive advantage for the customers.

Compressed Natural Gas and Piped Natural Gas have been accepted as alternative fuels by the public at large. The stage is set for expanding the network to other cities. The success of CNG & PNG Expansion Programs would depend on many factors. The key factors are the economy of CNG & PNG vis-à-vis other conventional fuels, and the quality of the product and environment friendliness adherence to safety guidelines and the Government Support. The emphasis would be on fuels with lowest emissions. However, CNG & PNG will be here for the time being till a better fuel is discovered offering better economics to the users.

City Gas Regulatory framework has been studied on a broad perspective. It has been compared to the Developed and Matured markets and recommendations have been suggested for regulatory framework of Indian Gas sector in order to move from the Emerging market to the Matured market.

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APPENDIX – I

Initiatives to fill Demand and Supply Gap

We have read in the last chapter that there is a potential gap between domestic gas demand and supply. Not only supply of gas can mitigate the demand supply gap. There are other sources of energy which can bridge the gap between demand and supply. We will work out all the possible options to minimize the gap between the demand and supply of gas.

INDIGENOUS E&P

New Exploration Licensing Policy (NELP) – Along with pre NELP and NELP nearly 138 Production Sharing Contracts (PSC) have been signed under 5 rounds of NELP which are under different stages of implementation. 36 discoveries have been made over the past seven years (1997-2004) and more than 800 million tons of oil and oil equivalent gas have been discovered.

NELP –VI is the recently concluded licensing round which offered 55 blocks and 52 blocks were bid for.165 bids were received in this round. preparation for NELP – VII round of bidding have already started. As many as 80 blocks are expected to be offered under this bidding round.

India is close to finalize Open Acreage Licensing Policy (OALP) which gives Companies around the year window to pitch for oil & gas in blocks of their choice. OALP will be offered along with NELP VII in June or July. OALP allows investors a continuous window of exploration opportunities. They will have access of data round the year.

LNG IMPORT

There are three existing LNG terminals in India. Many more are proposed Eastern and southern coasts.

Dahej:

The Petronet LNG is the first LNG terminal commissioned in India at Dahej, Gujarat April 2004. The existing capacity of the Dahej terminal is 5 MMTPA (18 MMSCMD).GAIL, Oil and

Natural Gas Corporation (ONGC), Indian Oil Corporation (IOC) and Bharat Petroleum Corporation Limited (BPCL) have formed the company. Gaz de France has 10% equity in the company as a strategic partner and the Asian Development Bank has 5 percent equity.

The LNG comes in Dahej terminal from Qatar's RasGas LNG project, and the gas from the Dahej LNG terminal is distributed to Gujarat, Madhya Pradesh, Uttar Pradesh, Rajasthan, Haryana, and Delhi, through newly built Dahej – Vijaipur and Hazira – Vijaipur – Jagdishpur (HVJ) pipeline.

Terminal's operating capacity is 10 MMTPA. So PLL has planned to expand capacity to 10 MMTPA by 2008 by obtaining gas from RasGas as contracted in 2005.

Shell-Hazira:

The second LNG terminal of 2.5 MMTPA capacity was commissioned in 2005 by Shell. The terminal received its first cargo in April 2005. Here spot trading is done. The LNG cargo is bought from Australia, Oman, Qatar, and elsewhere. Furthermore, Total has bought a 26 percent stake in Hazira

Ratnagiri Gas and Power Pvt. Ltd. (RGPPL) LNG Terminals Dabhol

Dabhol Power Company (DPC) had been abandoned for more than five years due to internal problem of the company. This terminal is in the process of renovation after assets were acquired by RGPPL. This terminal is expected to be commissioned by mid 2007. The initial capacity is 5 MMTPA, RGPPL would use 2.1 MMTPA of LNG for power generation and remaining 2.9 MMTPA would be sold off.

Proposed LNG Terminals:

Many new LNG terminals are being planned in Gopal Pur (Orissa) Mangalore (Karnataka) Kochi (Kerala), Pipava (Gujarat), Ennore (Tamil Nadu).

CROSS BORDER PIPE LINE

India is having a quite few proposed cross border pipelines which are being seriously talked about to minimize the demand supply gap for gas. Some of the various cross border pipeline projects are given below.

Iran – Pakistan – India Pipeline: It is 2100 km length pipeline project of $ 7.4 billion budget. But pricing of gas is the problem for commencement of the project. In June 2005 supply of 5 MT/Yr supply of LNG was agreed at a price of $ 3.215 per MBtu. Delhi was planning to import additional LNG of 2.5 MT/Yr at $ 4.78 per MBtu. The average price for total 7.5 MT becomes $ 3.74 per MBtu. But Iran wants to price the additional 2.5 MT at $ 7.92 per MBtu and average price for 7.5 MT becomes $ 4.78 per MBtu. Extensive talks are going on between India, Pakistan, and Iran at the Government / Ministerial levels.

Myanmar – India Pipeline: Daewoo, GAIL, ONGC and KOGAS consortium has discovered gas in a offshore block of Myanmar. The option of pipeline through Bangladesh is being kept in mind. Pipeline through North East region is not ruled out even.

Turkmenistan –Afghanistan- Pakistan Pipeline to India: A place in Turkmenistan which is near to Afghanistan has reported to have sufficient gas reserves. The Governments of Turkmenistan – Afghanistan – Pakistan (TAP) proposed gas pipeline. They have invited India to participate in the project. India is seriously evaluating the feasibility of the project.

EQUITY GAS ABROAD

Indian Oil and Gas Companies are going global by acquiring stake in foreign companies. This move is encouraged by Government to increase the Energy security of the Country. It will also allow the country with persistent supply with energy.

- OVL (ONGC Videsh Ltd.) is operative in 16 countries.
- OVL has own its 2 Oil Blocks in Brazil with probably 100% stake.
- OVL has 20% stake in Sakhalin-I project which will give India 2.4 MT of Oil per year.
- OVL will also seek an agreement with Rosneft for development of the Vankor Oil field.

- ONGC & Eni (Italy's company) signed an agreement to share each of their shares. Eni will get 34 % equity in ONGC's deep water Mahanadi basin. Through this agreement ONGC will get technological expertise for deep water exploration. ONGC's OVL will get 20% participating interest in Eni's MTPN exploration block in Congo Brazzaville.
- OVL has signed EPSA with Libya's national Oil corporation for exploration of the African country's offshore contract area 43.
- Reliance Industry is all set to build 50,000 barrels per day green field refinery in Yemen. For 1st five months product has to be sold in the domestic market and than it can export. It will partner Hood Oil in two oil blocks.
- Prize Petroleum, the exploration arm of HPCL who recently own a block in NELP VI is in talk to buy an Egyptian Oil exploration company.
- Petroleum Minister will visit Libya &Yemen to secure Oil fields and Refinery business for Indian public sector. OIL & IOC intend to expand their participation in Libyan E&P sector where they earlier won exploration blocks.

OTHER INITIATIVES

CBM

A gas similar to natural gas with 90% methane which is trapped inside Coal Bed and is an eco-friendly source of energy. In India approximately 850 BCM of CBM Gas reserves are estimated. In the coming years, around 21 MMSCMD gas is expected to be produced through CBM with an approximate cost of 5.5 US$ / MMBTU.

IN SITU GASIFICATION

Coal gasification is a viable option for Urea production with delivered coal price of 2.5 US$/MMBTU. Underground Coal gasification (UCG) is in-situ gasification of coal in the seam. It is achieved by injecting oxidants, gasifying the coal and bringing the product gas to the surface through boreholes drilled from surface. India has large reserve of coal and lignite at un-mineable depth which can be tapped through UCG. The lignite reserve at Mehsana, Ahmedabad block in Gujarat block alone contain recoverable gas reserve of 15,000 Billion cubic meter equivalent of natural gas utilizing UCG. ONGC and GAIL are exploring the possibility of exploiting coal gas by UCG technology.

GAS HYDRATES

Gas Hydrates are non-stoichiometric crystalline compounds that belong to the inclusion group known as Clathrates. Hydrates occur when water molecules attach themselves together through hydrogen bonding and form cavities which can be occupied by a single gas or volatile liquid molecule. The presence of a gas or volatile liquid inside the water network thermodynamically stabilizes the structure through physical bonding via weak van der Waals forces.

Naturally occurring hydrates are being looked upon as a future energy source and a potential global climate hazard. These naturally occurring hydrates, containing mostly methane, exist in vast quantities within and below the permafrost zone and in sub sea sediments. At present the amount of organic carbon entrapped in hydrate exceeds all other reserves (fossil fuels, soil, peat, and living organisms). On the other hand, if global warming occurs, the temperature will rise and decompose some of these methane hydrates in the earth. Methane is one of the most harmful greenhouse gases and this effect could be potentially threatening.

So far, World estimates have converged on a consensus value of about 21,000 trillion cubic meters of methane in natural gas hydrates which is more than 100 times of world NG reserve. The drilling/coring for gas hydrates is a very specialized activity, and India will be third country in the world to do so, after USA and Japan. Pilot test production is planned to be carried out in India by 2009/10. Research work is under progress at various parts of world to find out a suitable technology for production of gas from gas hydrates in a safe, economical and environmentally acceptable way.

BIO MASS

Ethanol made from cellulosic biomass is called bio ethanol. In the coming years it is believed that cellulosic biomass will be the largest source of bio ethanol. The broad category of biomass for the production of ethanol includes agricultural crops & residues and wood. Biomass resources are abundant and have multiple application potential. The crops residues such as rice straw, bagasse etc are not currently used to derive desired economic and environmental benefits and thus they could be important resource bases for bio ethanol production. The table below indicates potential of such biomass for ethanol production.

Potential for ethanol from cellulosic matter

Feed Stock	Gallons Ethanol / Dry Tons
Bagasse	112
Corn stover	113
Rice Straw	110
Forest Thinning	82
Hardwood Sawdust	101
Mixed paper	116

Technology Involved:

There are four technologies to produce Bio-Ethanol. The first three are based on producing sugars from biomass and then fermenting the sugars to ethanol. The fourth is a very different approach involving thermal processing of biomass to gaseous hydrogen and carbon monoxide, followed by fermentation to ethanol. The ethanol demand for blending can be calculated from the plan projection of the future growth in gasoline use. The tables below provide the figures for the tenth plan together with the availability.

Another renewable fuel which can be derived from Bio mass is bio gas

Biogas is a mixture of methane (CH4), carbon dioxide (CO2), and depending on the feedstock used, trace gases such as nitrogen, ammonia (NH3), sulfur dioxide (SO2), hydrogen sulfide (H2S), and hydrogen Methane is the main component of biogas. It is relatively clean burning, colorless, and odorless. This is already being done on a large scale in some countries of the world Biogas is produced when certain bacteria decompose organic material in an anaerobic (no oxygen is present) environment. This process is referred to as anaerobic digestion (AD).

The Biogas plants are the cheap sources of energy in rural areas. Animals that eat a lot of plant material, particularly grazing animals such as cattle, produce large amounts of biogas. The biogas is produced not by the cows themselves, but by billions of microorganisms living in their digestive systems. Biogas also develops in bogs and at the bottom of lakes, where decaying organic matter builds up under wet and anaerobic conditions. Besides being able to live without oxygen, methane-producing microorganisms have another special feature: They are among the

very few creatures that can digest cellulose, the main ingredient of plant fibers. Another special feature of these organisms is that they are very sensitive to conditions in their environment, such as temperature, acidity, the amount of water, etc.Biogas is a good fuel. Have you thought how this is formed? Biomass like animal excreta, vegetable wastes and weeds undergo decomposition in the absence of oxygen in a Biogas plant and form a mixture of gases. This mixture is the biogas. Its main constituent is methane. This is used as a fuel for cooking and lighting.

Components of Bio Gas

component	Symbol	Percentage
Methane	CH4	40-70
Carbon dioxide	CO2	30-60
Hydrogen	H2	1.0
Nitrogen	N2	0.5
Carbon Monooxide	CO	0.1
Oxygen	O2	0.1
Hydrogen Sulphide	SH2	0..1

BIO DIESEL

Bio-diesel is an eco-friendly, alternative diesel fuel prepared from domestic renewable resources i.e. vegetable oils (edible or non- edible oil) and animal fats. As India is deficient in edible oils, non-edible oil may be material of choice for producing bio diesel. For this purpose Jatropha curcas considered as most potential source for it. Presently, in some Indian villages, farmers are extracting oil from Jatropha and after settling and decanting it they are mixing the filtered oil with diesel fuel. Although, so far the farmers have not observed any damage to their machinery, yet this remains to be tested and PCRA is working on it. The fact remains that this oil needs to be converted to bio-diesel through a chemical reaction - trans-esterification. Sources of Bio-diesel are all Tree Bearing Oil (TBO) seeds - edible and non edible. Edible: Soya-bean, Sun-flower, Mustard Oil etc. Non-edible: Jatropha Curcas, Pongemia Pinnata, Neem etc. Jatropha Curcas is a widely occurring variety of TBO It grows practically all over India under a variety of agro climatic conditions. Can be grown in arid zones (20 cm rainfall) as well as in higher rainfall zones and even on the land with thin soil cover. Its plantation can be taken up as a quick yielding plant even in adverse land situations viz. degraded and barren lands under forest and non-forest use, dry and drought prone areas, marginal lands, even on alkaline soils and as agro-forestry crops. It grows as a tree up to the height of 3 - 5 m.

Agencies & Institutes working in the field of bio-diesel are as follows:

National Oil seeds and Vegetable Oil Board, Gurgaon

PCRA - Petroleum Conservation Research Association (MOP&NG)

IOC (R&D) Centre, Faridabad

Delhi College of Engineering

IIT, Delhi

IIP, Dehradun

Downstream National Oil Companies

Indian Institute of Chemical Technology, Hyderabad

CSIR

Ministry of Non-conventional Energy Sources

Central Pollution Control Board

Bureau of Indian Standards

Indian Renewable Energy Development Agency

State wise area undertaken by NDVOD for Jatropha plantation

State	Area (ha)
Andhra Pradesh	44
Bihar	10
Chhatisgarh	190
Gujarat	240
Haryana	140
Karnataka	80
Madhya Pradesh	260
Maharashtra	150
Mizoram	20
Rajasthan	275
Tamil Nadu	60
Uttaranchal	50
Uttar Pradesh	200

HYDROGEN ENERGY

It does not occur freely in atmosphere and it require an integrated system development approach covering production, storage, transportation, delivery and end use application and associated devices requiring major investments.

The advantages of Hydrogen Energy

- Decentralized sources of energy
    - Bottlenecks
- Overcoming technical and non technical barriers including productions, delivery, storage and safety
    - Security of supply
- Enhances energy security
    - Price
- Very high capital cost
    - Environment
- Eliminates air pollution -NOx, SOx, CO2

WIND ENERGY

An estimated 1% to 3% of energy from the Sun that hits the earth is converted into wind energy. Most of this wind energy can be found at high altitudes where continuous wind speeds of over 160 km/h (100 mph) occur. The various uses of wind energy are

-Water pumping through wind mills

-Onshore wind turbines

-Offshore wind turbines

India has a potential 45,000 MW of wind energy. Only 5,340 MW of this energy is exploited so far. In India the largest capacity wind turbine of 1650 kW has been recently installed in Tamil Nadu by one of the manufacturers.

SOLAR ENERGY

Solar energy, or solar power, is the energy from the light of the sun. It gives unlimited Supply for "Free". It causes no pollution (after manufacture of cells).It is being predicted that Solar energy will dominate world energy production by 2050. There are two kinds of solar energy direct and indirect solar energy. Only single transformation of sunlight which results in a useable form of

energy called direct solar energy. For example Sunlight hits a photovoltaic cell, creating electricity, Sunlight warms a thermal mass. Multiple transformations of sunlight which result in a useable form of energy called secondary solar energy. For example vegetation uses photosynthesis to convert solar energy to chemical energy. Through solar energy and its interaction with the Earth's atmosphere, wind turbines and hydroelectric dams are powered.

India is positioned in a strategic geographic location. India is one of the highest receivers of solar energy. India receives nearly 5000 trillion KW hr/year of solar energy. Many of the European countries which receive much less solar energy use solar energy more than India. According to the European Renewable Energy Council, the solar market supplies only one per cent of the world's energy needs and is worth an estimated $7 billion annually. The industry hopes to increase that proportion to eight per cent by 2030.

India has plenty of sunlight and areas like Rajasthan offer favorable conditions for the harnessing of solar energy. Photoelectric cells have emerged as the most promising route to solar power generation. Over the years, power cells have become more efficient, and cost-effective and the high cost of oil is a strong incentive to actively encourage and promote the production and use of solar cells. In India, solar cells are supplying electricity to many homes in cloudless Ladakh. The scattered villages of the Sunderbans are drawing electricity from solar power rather than the long T&D lines. The solar cells have proved to be a viable alternative, even now, under specific conditions. As the cost of solar power declines further, more and more locations in India will find it an attractive option.

TIDAL ENERGY

The movement of the tides has to do with the gravitational force of the Moon and Sun, and also the rotation of the Earth. Ocean contains energy in the form of temperature gradients, waves & tides and ocean currents. First tidal power station in the world was constructed in France in 1965 across the Rance River with 240 MW capacity.

A dam or barrage is built across an estuary or bay that experiences a significant tidal range (more than 5 meters). The purpose of this dam or barrage is to let water flow through it into the basin as

the tide comes in. The barrage has gates in it that allow the water to pass through. The gates are closed when the tide has stopped coming in, trapping the water within the basin or estuary and creating a hydrostatic head. As the tide withdraws, the gates in the barrage that contain turbines are opened. The hydrostatic head causes the water to come through these gates, moving the turbines and generating power

Advantages:

-After one spends the initial money to build it, tidal power is free.

-It doesn't produce any greenhouse gases or waste!!

-It doesn't need fuel!!

-The tides are completely predictable.

-It's reliable.

Disadvantages:

-It only provides power for about ten hours every day, at times when the tide is moving in and out.

-Barrages are expensive to build.

-Environmental damages:

- Land is changed for miles upstream and downstream.
- Birds' eating patterns are disrupted because they rely on the tide to uncover the mud flats so they can eat.

-There are very few suitable sites for tidal barrages.

NUCLEAR ENERGY

TAPP-4, which started commercial production in September 2005, is the 15th nuclear plant in the country. It is the first 540 MW plant. It is desirable to develop nuclear power, particularly in view of the uneven distribution of coal and lignite, the need to reduce dependence on the import of fossil fuels and minimize air pollution. The growth of nuclear power, which has been slow, is planned to increase much faster. Even so, in the short and medium term, its contribution to total installed capacity will be modest. India is fortunate that its nuclear sector was given shape and nurtured by a visionary like Dr Homi Baba. He drew up a three-stage development plan with the object of using India's large deposits of Thorium for power generation. On the basis of his blueprint, despite sanctions, India has developed technology and the capacity to manufacture

sophisticated plant, equipment, reactors and other hardware, and has mastered the complete fuel cycle. The Fast Breeder Test Reactor (FBTR) has been in operation for some years now and the prototype fast breeder reactor (PFBR) is under construction. Unwavering effort should be directed to execute Baba's plan to harness Thorium for power production. That should be the focus of policy. India is in talk with USA for nuclear supply for domestic use. If successfully the deal is completed it will boost India's Energy security.

HYDRO POWER

Over the years, the proportion of hydropower in the thermal-hydro mix has been declining steadily. In the early Seventies, it was roughly 60:40. Thermal stations were supposed to be base load stations and hydropower met peak load demand. Today, there is an overall power shortage, both in terms of energy and peak. The management of the grid is helped by a larger hydropower capacity. Besides, hydropower has the advantage of using a renewable resource and not causing air pollution. Hydropower potential has been assessed at 84,000 MW at 60 per cent load factor (140,000 MW installed capacity) apart from small, mini and micro hydel schemes (10,000 MW) and pumped storage schemes. As against this, the installed capacity of hydropower comes to around 32,000 MW. Many factors have contributed to the slower growth of hydel capacity. The gestation period of hydel projects is longer, and the pressure of stepping up generation to keep up with rising demand tends to divert investment to thermal plants. Over the years, hydel projects have already been built on the more accessible sites. Most of the unexploited potential is in the Northeast and the higher mountain ranges. These projects are generally more difficult to execute in comparison with those elsewhere. Moreover, large dams face greater resistance both on environmental and ecological grounds, and on politically sensitive relief and rehabilitation issues. To sum up, while it is clear that Energy policy must promote hydropower, it must, at the same time, be responsive to legitimate public concerns.

APPENDIX – II

CNG ACTIVITIES IN INDIA OVER THE YEARS FROM 2002-05

CNG ACTIVITIES IN INDIA (AS ON 1.4.2002)

Item	Delhi	Maharashtra	Gujarat				Grand Total
	IGL	MGL	Vadodara GAIL	Surat GGCL	Ankleshwar GGCL	Total	
Station Type							
Mother	25	2	1	1	0	2	29
Online	13	9	0	1	0	1	23
Daughter Booster	26	13	0	0	0	0	39
Daughter	30	1	2	1	1	4	35
Total	**94**	**25**	**3**	**3**	**1**	**7**	**126**
No. of Vehicles							
Cars	15166	27325	152	636	103	891	43382
Autos	36565	7853	0	429	0	429	44847
RTVs	2165	0	0	0	0	0	2165
Buses	4231	46	0	0	0	0	4277
Total	**58127**	**35224**	**152**	**1065**	**103**	**1320**	**94671**
Price (Rs./Kg)	**13.11**	**19.71**	**13.31**	**19.73**	**20.39**		
Average Consumption							
TPD	355.00	118.91	0.39	1.67	0.19	2.25	476.16
MMSCMD	0.4416	0.1665	0.0005	0.0021	0.0002	0.0028	0.5923

CNG ACTIVITIES IN INDIA (AS ON 1.4.2003)

Item	Delhi	Maharashtra	Gujarat				Grand Total
	IGL	MGL	Vadodara GAIL	Surat GGCL	Ankleshwar GGCL	Total	
Station Type							
Mother	25	2	1	1	0	2	29
Online	13	9	0	1	0	1	23
Daughter Booster	26	13	0	0	0	0	39
Daughter	30	1	2	1	1	4	35
Total	**94**	**25**	**3**	**3**	**1**	**7**	**126**
No. of Vehicles							
Cars	15166	27325	152	636	103	891	43382
Autos	36565	7853	0	429	0	429	44847
RTVs	2165	0	0	0	0	0	2165
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Price (Rs./Kg)	**13.11**	**19.71**	**13.31**	**19.73**	**20.39**		
Average Consumption							
TPD	355.00	118.91	0.39	1.67	0.19	2.25	476.16
MMSCMD	0.4416	0.1665	0.0005	0.0021	0.0002	0.0028	0.5923

CNG ACTIVITIES IN INDIA (AS ON 1.4.2004)

Item	Delhi	Maharashtra	Gujarat				Grand Total
	IGL	MGL	Vadodara GAIL	Surat GGCL	Ankleshwar GGCL	Total	
Station Type							
Mother	56	4	1@	1	0	2	**62**
Online	27	56	0	1	0	1	**84**
Daughter Booster	33	15	0	0	0	0	**48**
Daughter	4	0	1	0	1	2	**6**
Total	**120**	**75**	**2**	**2**	**1**	**5**	**200**
No. of Vehicles							
Cars$	16098	48307	89	771	117	977	**65382**
Autos	59027	73139	0	459	0	459	**132625**
RTVs	5267	0	0	0	0	0	**5267**
Buses	10199	50	0	0	0	0	**10249**
Others	0	85	0	0	0	0	**85**
Total	**90591**	**121581**	**89**	**1230**	**117**	**1436**	**213608**
Price (Rs./Kg)	**16.83**	**19.71**	**18.20**	**21.45**	**21.45**		
Average Consumption							
TPD	886.5	NA	0.775	NA	NA		
MMscmd	1.148	NA	0.001	NA	NA		

CNG ACTIVITIES IN INDIA (AS ON 1.4.2005)

Item	Delhi	Maharashtra	Gujarat				Grand Total
	Delhi	Maharashtra	Vadodara	Surat	Ankleshwar	Total	
	IGL	MGL	GAIL	GGCL	GGCL		
1	2	3	4	5	6	7	8
Station Type							
Mother	59	4	1@	0	0	1	64
Online	34	88	0	5	1	6	128
Daughter Booster	38	13	1	0	0	1	52
Daughter	4	0	0	0	1	1	5
Total	**135**	**105**	**2**	**5**	**2**	**9**	**249**
No. of Vehicles							
Cars$	16249	49983	89	1514	356	1959	68191
Autos	62048	95921	0	8353	73	8426	166395
LCV/RTVs	5193	1004	0	0	0	0	6197
Buses	10480	90	0	19	0	19	10589
Others/Phatphat Sewa	276	538	0	1	1	2	816
Total	**94246**	**147536**	**89**	**9887**	**430**	**10406**	**252188**
Price (Rs./Kg)	16.88	19.77120.10 #	18.20	22.55	22.55		
Average Consumption							
TPD	922.245	495.45/0.08 #	0.95	NA	NA		
MMSCMD	1.211	0.7/0.001 #	0.001	NA	NA		

MMscmd: Million Standard Cubic Metres Per Day
TPD: Tonnes Per Day
$: Includes Taxes
@: Cascade filling facility only
NA: Not Available

Source:

1. IGL: Indraprastha Gas Ltd.
2. MGL: Mahanagar Gas Ltd.
3. GAIL: GAIL (India) Ltd.
4. GGCL: Gujarat Gas Company Ltd.