

NATURAL GAS VEHICLES IN EGYPT CHALLENGES AND PROSPECTS OF A GROWING INDUSTRY

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ABSTRACT

Growing industrialization, if not mere population growth, on the face of the Earth will induce organizations and nations world wide to reconsider the variety, priority, and efficiency of their energy sources.

Natural gas has become the world's premier energy source because it is efficient, adaptable, and environmentally safer than other fossil fuels.

The vehicular sector is a growing and major fuel consuming sector in any economy. Technological advancements and the flow of funds in that industry have allowed nations to target that sector as a priority in a plan to achieve maximum adaptation to natural gas consumption.

The use of compressed natural gas vehicles dates back to the 1930's in Italy. The late 70's however witnessed the launch of and commitment to a growing and developing industry. Today there are 3 million natural gas vehicles world wide with major concentrations in Argentina, Brazil, Italy, Pakistan, USA, and Egypt. The majority of these vehicles are converted gas vehicles adapted to use CNG in bi-fuel systems.

In 1992, Egypt initiated the use of Compressed Natural Gas (CNG) as a fuel in transportation. Since then, it has taken a leading role in the

Middle East and Africa in CNG adaptations to vehicles and currently ranks 8th worldwide with respect to its CNG fleet.

A combination of resource availability, dedicated inter-ministerial efforts, and discern by senior government officials of the importance of developing the project, will ensure Egypt's world wide precedence in the industry benefiting from economic, social, and environmental returns.

There is an accelerated trend in the use of natural gas with the advancement in its use as a feedstock and reducing agent or in power generation, heating, air conditioning, transportation technologies, incremental oil extraction as well as other industrial and commercial applications. Environmental protectionists, energy strategists as well as private institutions will turn much of their attention to natural gas in the near future.

One major natural gas consumption parameter will definitely be the Natural Gas Vehicles Industry.

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I.INTRODUCTION

Growing industrialization, if not mere population growth, on the face of the Earth will induce organizations and nations world wide to reconsider the variety, priority, and efficiency of their energy sources. Natural gas has become the world's premier energy source because it is efficient, adaptable, and environmentally safer than other fossil fuels. The vehicular sector is a growing and major fuel consuming sector in any economy. Technological advancements and the flow of funds in that industry have allowed nations to target that sector as a priority in a plan to achieve maximum adaptation to natural gas consumption. One major natural gas consumption parameter will definitely be the Natural Gas Vehicles Industry.

The natural gas vehicles industry, being in the development stage, is constantly challenged by inherent as well as newly arising constraints. The successful surpassing of this stage will guarantee future sustainability and dominance of CNG as the primary source of transportation fuel world wide. The fact that natural gas runs cleaner than most fuels, minimizing vehicle emissions related pollution, and the growing estimated for natural gas reserves, further enhance the assessment of the industry's feasibility in all means. Such economic and environmental motives will certainly prevail over misperceptions concerning technical efficiency, cost, and safety of vehicle conversions.

The use of compressed natural gas vehicles dates back to the 1930's in Italy. The late 70's however witnessed the launch of and commitment to a growing and developing industry. Today there are 3 million natural gas vehicles world wide with major concentrations in Argentina, Brazil, Italy,

Pakistan, USA, and Egypt. The majority of these vehicles are converted gas vehicles adapted to use CNG in bi-fuel systems.

In 1992, Egypt initiated the use of Compressed Natural Gas (CNG) as a fuel in transportation. Since then, it has taken a leading role in the Middle East and Africa in CNG adaptations to vehicles and currently ranks 8th worldwide with respect to its CNG fleet. A combination of resource availability, dedicated inter-ministerial efforts, and discern by senior government officials of the importance of developing the project, will ensure Egypt's world wide precedence in the industry benefiting from economic, social, and environmental returns.

There is an accelerated trend in the use of natural gas with the advancement in its use as a feedstock and reducing agent or in power generation, heating, air conditioning, transportation technologies, incremental oil extraction as well as other industrial and commercial applications. Environmental protectionists, energy strategists as well as private institutions will turn much of their attention to natural gas in the near future.

II.OVERVIEW OF THE INDUSTRY AND DEVELOPMENTS

The NGV industry has met special attention from the Government of Egypt (GOE) since the mass inauguration of the project in 1996 and the establishment of two CNG proving companies. Consistent efforts by the Ministry of Petroleum (MOP) and further by the Egyptian Natural Gas Holding Company (EGAS) have ensured the successful development of the industry whereby Egypt is now one of the top ten countries worldwide.

Six CNG companies are now licensed to operate in Egypt, providing conversion and maintenance services as well as building refueling stations. The successful market development efforts of the Natural Gas Vehicles Company (NGVC) – Cargas, and the Egyptian International Gas Technology Company (EIGTech) have proven to be attractive for other investors to join in the growing industry. Four additional companies with experience in the gas industry have entered the market in 2004. The close involvement of government entities and organizations like EGAS will also guarantee correct practices and optimal direction of investments all to the benefit of the consumer. For CNG customers and other stakeholders in the industry, the market seems more and more reliable in terms of technical support, pricing, and geographical coverage. Rigorous safety programs, standards, and the initiation of Original Equipment Manufacturers (OEMs) are also enhancing drivers for the CNG public acceptance.

In order to ensure the successful growth of the industry to cover various market segments with rising penetration rates, it is important that barriers and constraints to this development be identified and counteracted with feasible means in all respects. The growth of the CNG industry is a function of wide public acceptance of the conversions and their confidence in the continuing support by the government to ensure high quality standards and stringent safety measures. A major challenge facing stakeholders in the industry is the fact that at this development stage the idea of a bi-fuel setup is only accepted among consumer with an extreme need in economies of fuel consumption. The remaining market segments are reluctant due to several technical issues as well as varying misperceptions of the project. From the technical view point, there is a negative perception of gasoline vehicle users of the performance of CNG

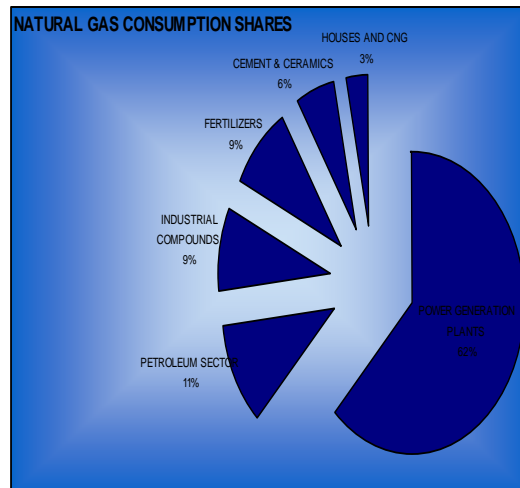
converted vehicles. Opinions given by mechanics and even non CNG users seem to affect a conversion decision greatly among private vehicle owners with a lower cost reducing incentive.

Technical issues raised include loss of power and acceleration, deterioration of engine performance, and more frequent oil changes. Such problems were found to be the case when the conversion process was of poor quality. CNG in Egypt is definitely well founded and supported by various stakeholders. The continuation of this progress and the success of new expansions will depend on efforts to counteract barriers present and forthcoming as in the normal introduction of a new industry.

A.TOWARDS A GAS POWERED EARTH

Demand projections show natural gas as the fastest growing energy source demanded worldwide. The power industry comprises more than half of this expected demand structure. Environmental concerns, technological advances and economies of fuel consumption will further induce the transition to natural gas as the world's primary energy source in the near future. Natural gas is challenging oil, both as a commodity and as the primary business of energy companies. Natural gas is the most qualified option among energy sources to meet our requirements for decades to come. Below is a pie chart depicting natural gas consumption shares in Egypt.

The deregulation and restructuring of the natural gas industry in many industrial and developing countries have led to the development of new markets that have altered the way the industry operates. Two major markets emerge as a result of deregulation: A trading platform for natural gas as a commodity and surprisingly an expansion in the transportation sector as well.



The increase in oil consumption is contributing to the degradation of air quality worldwide. Green house gases such as carbon dioxide and methane contribute to the global warming phenomena. These gases absorb infrared heat loss from the Earth's surface to outer space.

B. TRANSITIONAL CONSTRAINTS AND CHALLENGES

A well integrated plan for the development of vehicles and refueling stations is needed to achieve large scale transition to using natural gas as an alternative fuel to vehicles. Several crucial factors must be incorporated at this stage to ensure a successful implementation:-

1. Realizing the lack of awareness among the public requires emphasis on training efforts and mass media endeavors. The industry holds employment potentials and economic gains enough to contribute in raising standards of living.

2. Statutory governmental subsidies or incentive for the industry must be stable over a reasonable period of time to as not to disturb the gradual market transition.
3. From the suppliers' side, coordinated efforts within stakeholders must be allocated to optimal distribution of refueling stations and service centers.
4. Technical issues associated with converted vehicles must be settled either by raising the quality of conversions or efforts to correct misinterpretations among CNG customers.
5. Continual evaluation of the investment cost structure of stations and conversions.

In order for such factors to be considered and regularly revised by policy makers and planners in the industry, a comprehensive information system needs to be developed and maintained throughout the various stages of the industry.

Some industry barriers will have to be overlooked for the time being; the fact that there is no economic feasibility in diesel conversions (dual-systems) will remain for a while leaving no penetration whatsoever in this market segment. This infeasibility is basically a result of two reasons: 1) CNG has no favorable price differential to diesel. 2) The conversion cost of diesel vehicles is a lot more expensive due to several technical aspects.

In summary, the price difference between CNG and gasoline was the motivating cost factor behind most conversions, however, technical and performance related issues, refueling stations and public perceptions are viewed as potential barriers to market growth.

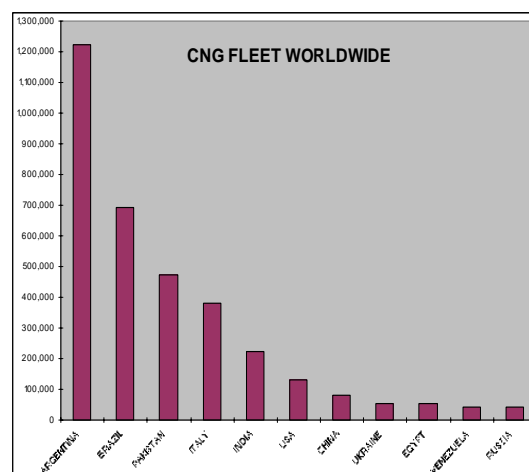
C.INTERNATIONAL EXPERIENCES WITH NGVS

In Egypt, there is a great interest to reduce vehicle emissions, however the primary drivers to initiate the NGV project were establishing a diversified energy dependency, lower consumer cost for fuels, and supporting exports of oil products by freeing up reserves for such purposes. Today Egypt has the 9th largest fleet worldwide. Other countries have taken NGV initiatives with more or less similar motives. A wide scale of successes and failures could be derived among the experiencing countries. Measuring the success of those countries could be denominated in the number of NGV vehicles, number of refueling stations, geographic coverage, and growth in term of conversions and number of stations.

1. ARGENTINA

Argentina is the world leader in CNG. During the last decade, Argentina witnessed tremendous growth in the CNG industry at a rate of 8000 vehicle conversions per month to reach a total of 1,223,161 converted vehicles with over 1,200 refueling stations. Most converted vehicles are individually owned passenger cars running on a bi-fuel system.

Fuel taxes in Argentina are favorable towards natural gas. The private sector has been building on



the government incentives and today is driving the industry through continual growth and development. A good safety record, compliance to standards, a well developed network, and regular training have all added to public acceptance and support of the project.

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2. ITALY

With over 400,000 vehicles and 470 refueling stations, Italy has the largest experience in NGV. In addition to conventional objectives for energy diversification and environmental preservations, Italy has also supported the project to preserve historic buildings, land marks and artwork. Poor dispersion of refueling stations has limited penetration in the taxi segment. However CNG's price is favorable to compared to both gasoline and diesel.

OEMs are starting to play a role in developing the industry raising its prospects in the coming years. Several initiatives for conversions, stations construction as well as regulations on CNG fleet are promoting the growth. It is surprising that almost all of Italy's natural gas is imported; however a well developed natural gas distribution system exists. Still, remote CNG station locations remain to be a challenge. Italy will remain as one of the pioneers of the industry due to the vast

knowledge in CNG station and equipment technologies and the presence in OEMs in stations as well as vehicles and conversion kits.

3. BRAZIL

Brazil started the CNG program initially to convert bus fleets and cargo fleet. Today Brazil has the second largest CNG fleet in the world with over 690,000 vehicles and over 740 refueling stations.

In Brazil, CNG prices are favorable to both gasoline and ethanol but not diesel. The project initially did not give promising results due to technical limitations and economic infeasibility of converting diesel run buses.

4. UNITED STATES

The NGV program in the US was primarily driven by energy concerns and diversity of energy sources. The US government issued mandating legislation for bus fleet conversions to CNG. There have also been tax reductions for the purchase of clean fuels and on establishments like refueling stations. The program was launched in the late 1980s and now there are approximately 130,000 vehicles running on natural gas and a network of 1,300 refueling stations. Growth seems to be supported by a good gas pipeline structure and no penetration barriers among diesel fleets due to government mandates.

5. CANADA

The abundance of natural gas locally, high oil import prices, environmental concerns, and special devotion of public spending on environmental initiatives and environment friendly technology induced CNG inauguration in the mid 1980s and in its early stage the project succeeded to convert 15,000 vehicles and build 80 refueling facilities within gasoline facilities.

Although CNG had a price advantage and conversion kits were available locally, still the high labor costs slowed down conversions to stop at 21,000 with 140 public and 85 existing private refueling stations. Now there are no air quality concerns in Canada and no regulations mandating conversions.

6. UNITED KINGDOM

The UK has less than 1,000 vehicles and under 20 refueling stations. Lack of a price advantage, substantial government support and commitment has not promoted CNG vehicle development. The UK has initiated mandatory regulations for the use of ultra-low sulfur diesel fuel (ULSD) effective in 2005. This will unintentionally take attention away from CNG programs since there will be capital commitments already rolling with and so delayed spending on CNG in the near future. The fact that emission regulations in the UK are focused on total hydrocarbons and not specifically non-methane hydrocarbons will give (ULSD) an advantage over CNG.

7. NEW ZEALAND

Rising oil prices in 1970s and the fact that the country imported 90% of its transportation fuel were behind the initiation of the program in 1979. A regulated fuel economy characterized by financial incentives for vehicle conversions and refueling station constructions, in addition to enhancing public awareness and conducting trainings, was a foundation for a successful industry development. However, political changes deregulated the oil industry and private companies removed CNG equipment from stations. Furthermore, the decline in global oil prices and the removal of the excise tax on diesel added to the infeasibility of the project.

8. INDIA

There are two major cities in India involved in the CNG program. The leading city is Delhi, capital of India. There is about 10,000 CNG buses and 60,000 CNG autorickshws (3-wheeled taxis) in Delhi and 15,000 other CNG vehicles for a total of 85,000 CNG vehicles. There have been some very clear stories about the environmental benefits of CNG in Delhi.

The other major program is in Mumbai (formerly called Bombay). There are also 60,000 CNG autorickshws and 50,000 other CNG vehicles for a total of 110,000 CNG vehicles. India has designated about 10 more cities for CNG but these other cities have not started the program in any significant way yet. However, a recently opened LNG facility on the West Coast of India was established to allow import of more natural gas. The fact that natural gas field are being discovered is another factor enhancing commercializing natural gas vehicles in India.

9. CHINA

China is a country with plenty of natural gas but shortage of oil. It is reported that 1.5×10^{12} Nm³ of natural gas has been found until the end of 1998. In the meantime, more and more automobiles have produced much pollution to the air with the process to China modernization. So the Chinese government decided to develop CNG automobiles in all of its cities to solve the problem of environmental pollution and adjust its energy sources structure.

China's CNG program is more difficult to describe because it is very spread out. There is not one government department or company responsible for implementation throughout all of China – individual cities are taking the lead. There are about 12 demonstration cities for CNG. Some cities have had active CNG programs for 50 years. There is about 75,000 CNG vehicles and maybe 250 refueling stations in China.

D.SUMMARY OF MAJOR LESSONS LEARNED FROM INTERNATIONAL CNG EXPERIENCES

- Lesson 1: CNG's price advantage over gasoline as set by varying fuel tax policies has been the primary drive for CNG development in countries. However, the absence of government subsidies allows for long term sustained growth.
- Lesson 2: The presence of a single organization (e.g. an inter-ministerial government agency) with full authority and responsibility to oversee the CNG industry will ensure transcendence above arising barriers.
- Lesson 3: Ongoing public education and quality training have been effective in promoting the NGV program.
- Lesson 4: A rigorous safety program, together with few accidents, enhanced public acceptance.
- Lesson 5: Technical knowledge in refueling stations and conversion components will induce increasing involvement in OEMs.

III.FUNDAMENTALS OF A SUCCESSFUL CNG INDUSTRY IN EGYPT

Market surveys have identified the numerous barriers relating to the use of CNG vehicles that could hinder the continued rapid development of the CNG market. The involvement of various stakeholders and adoption of the initiative by top government officials will however push the industry past challenging development stages.

A.STAKEHOLDERS AND NATIONAL ECONOMICS

Current reserves and availability of oil and natural gas resources in Egypt provide a clear signal that shifting the country's energy dependency from oil to natural gas is a prudent strategy. Reviewing statistics, we find that an accumulated 750 million cubic meters of gas sales since the launch of the project freed up 198 million gallon equivalents of gasoline (1.9 million barrels of crude oil). Realizing the strategic importance of maximizing the cost effective use of Egypt's growing reserves of natural gas, the Ministry of Petroleum (MOP) took pioneering steps in the early 90s to encourage the conversion of vehicles from gasoline to compressed natural gas.

There have been recognizable efforts by the MOP to support and lead the CNG project to definite progress. The executive steering committee was formed by top decision takers in the MOP and CNG industry in Egypt to solve all the constraints facing the industry and making the necessary contacts with other concerned bodies from other ministries and various stakeholders. The MOP set a ten year ambitious plan for the CNG industry as the target for the executive steering committee's agenda.

Adopting an integrated policy aligning the interests of all stakeholders, and sending the proper signal to current and future vehicle owners can guarantee a successful CNG program in Egypt.

Local Distribution Companies (LDCs) have played a major role in providing the necessary infrastructure for the geographic dispersion of CNG stations. In the forefront was GASCO. Established in 1997 with the main objective of operating the country national gas grid, GASCO has helped develop numerous CNG fueling stations through the installation of off-takes that connect stations to the national grid.

The government of Egypt awarded 20-year concessions to private LDCs during which period they are responsible for financing, building, and operating the gas distribution network within a designated geographic franchise area. This includes establishing connections with CNG fueling stations.

- **THE EGYPTIAN NATURAL GAS HOLDING COMPANY (EGAS)**

The Ministry of Petroleum (MOP) established EGAS in August of 2001 to focus on the development of the local gas industry and to ensure that Egypt maximizes the economic and environmental benefits of its gas resources. EGAS is the counterparty to exploration and production agreements, conducts planning and development activities for the gas sector, and oversees distribution, marketing and exporting activities. EGAS enhances technological advances through comprehensive studies and integration of expertise along all levels of the industry. EGAS maintains a database for natural gas developments and statistics

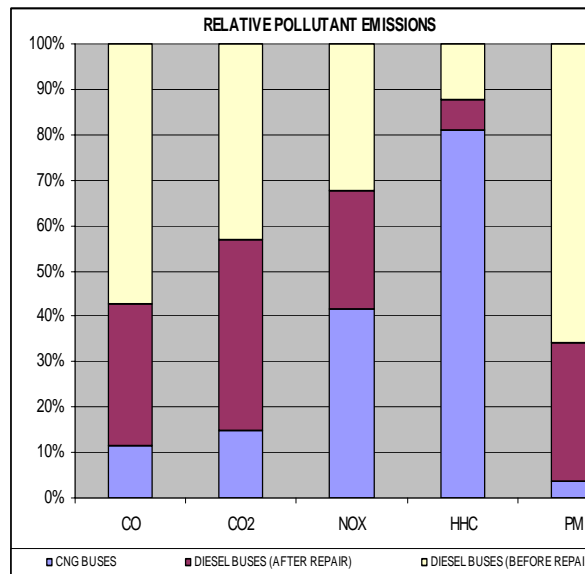
facilitating initiation of feasible projects and various regulatory endeavors. EGAS participates effectively in the establishment of gas marketing and distribution companies. EGAS has a vital role in expanding and maintaining the country's natural gas infrastructure as well as inducing local consumption of natural gas as an alternative fuel.

EGAS is taking a leading role in the education of new policy and market based initiatives that can accelerate the development of the local CNG vehicle industry. Moreover, due to the remarkable experience gained in this field, EGAS is initiating many efforts to transfer such experiences to other countries within the region.

B.ENVIRONMENTAL DRIVERS AND SAFETY STANDARDS

Natural gas is a clean burning fuel with a significant potential of reducing harmful emissions, especially those of particles, from vehicles. Vehicular particulate emissions in turn are a concern, because they are small (small particles are especially harmful to health) and numerous, and occur near ground level where people live and work.

There is growing epidemiological evidence that emissions from conventional fuel vehicles are extremely harmful to public health. Against this backdrop, natural gas vehicles are attracting increasing attention in developing country cities with serious air pollution as policy makers explore alternative to conventional fuel vehicles. Egypt, India, and Indonesia are among the developing countries to announce their intention to pursue the expansion of natural gas vehicles aggressively especially among public transport buses.



Natural gas consists of the lightest hydrocarbons, inert gases (such as carbon dioxide), and negligible sulfur.

In terms of energy content, 1 kg of NG is equivalent to about 1.3 liters of Gasoline and 1.2 liters of diesel. On a volume basis, 1 normal cubic meter of NG is equivalent to 1.1 liters of gasoline and 1.0 liters of diesel. NG however must be stored as CNG in order to have sufficient natural gas on board.

The volumetric energy content of the various fuels stored, expressed in mega joules (MJ) per liter, is shown in the table below.

Fuel	MJ/Liter	Relative to Gasoline	Relative to Diesel
Gasoline	32	1.0	0.9
Diesel	35	1.1	1.0
CNG	10	0.3	0.3
LNG	19	0.6	0.5

Advantages of natural gas as a transport fuel:

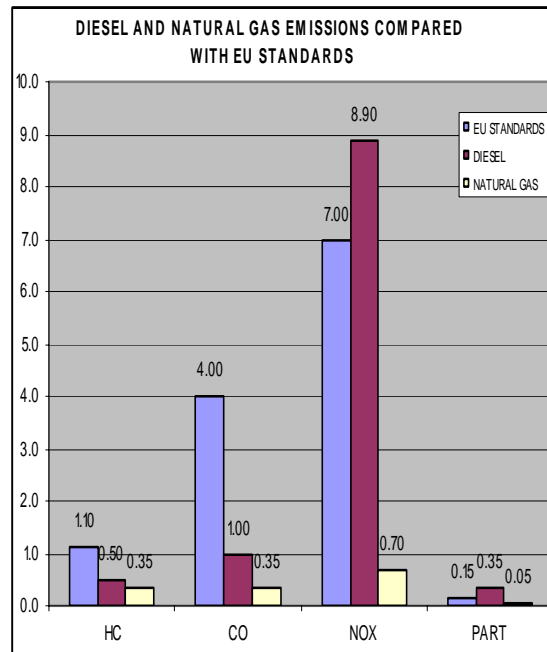
1. Very low particulate emissions
2. Low emissions of air borne toxins
3. Negligible sulfur oxides emissions
4. More quiet operation, with less vibrations and less orders

Disadvantages of natural gas as a transport fuel:

1. The occupied trunk space by the gas cylinder
2. The gas storage capacity within the available gasoline vehicles

Despite the negative impacts associated with the transition process to use natural gas as the primary vehicle fuel, still natural gas is the best solution for Egypt. Environmental degradation resulting from emissions and its consequences can be quantified and valued in money terms. The total damage of vehicle emissions in Egypt is estimated at approximately at EGP 4.5 billion. From an environmental perspective, diesel operated vehicles should also be targeted as they contribute most to emissions and in turn damage costs.

In May 1999, the Government of Egypt (GOE) and USAID signed an agreement to implement the Egyptian Environmental Policy Program (EPPP), which is a multi year program to support the development of the improved environmental policies. The Egyptian Environmental Government Affairs plays a leading role in the evaluation and establishment of standards for transportation vehicles. A rigorous safety program enhanced public acceptance, and safety records for stations as wells as for converted vehicles are also very good with few safety related accidents occurring in the last seven years.



As a sub-program task of EPPP, the Cairo Air Improvement Project (CAIP) was one of the major tasks that introduced CNG as a fuel for transit buses. 50 buses were funded by the program to run in Cairo as a pilot project. The lesson learned shows that CNG is the best alternative fuel for pubic buses.

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C.DEMAND ANALYSIS: CONSUMER BASE AND MARKET SEGMENTS

The fast growing Egyptian CNG market was most significant in the light transit sector. Taxis and gasoline operated minibuses proved to be the strongest candidates for CNG conversions due to their relatively high distance traveled. 60% of the total CNG fleet is located in Cairo, and CNG vehicles currently account for 1.25% of Cairo's 3.3 million vehicles.

A series of surveys and studies were conducted and demand side barriers to the market could be summarized as follows:-

1. The absence of a price advantage of CNG over diesel operated vehicles will hinder fast growth of the market since the diesel segment is substantial and growing.
2. Technical problems associated with the conversion.
3. Economics of the conversion.
4. Insufficient environmental regulations and lack of enforcement.
5. Lack of public awareness and existing misperceptions for the value added of the project on an individual as well as a national basis.

Penetrating the private sector will present a major challenge compared to other gasoline powered vehicles, because private sector vehicle owners are not mainly driven by the fuel price difference. However, as the CNG supply began to expand, private car conversions are increasing rapidly

D.SUPPLY ANALYSIS: CNG FUELING INFRASTRUCTURE

Private LDCs were awarded 20-year concessions in various governorates. LDCs are committed to financing, building, and operating the gas distribution network within a designated geographic franchise area. LDCs will also be responsible to connect CNG fueling stations to the natural gas grid. To date there are 8 LDCs operating in Egypt.

In this stage of development, the existing dispersion of stations is adequate however, for the purpose of encouraging more drivers to switch to CNG, the number of stations must be significantly raised and serving remote areas.

The site selection of refueling stations depends on:-

1. Access to the natural gas distribution network.
2. Land space availability.
3. Specifications and site selection requirements (e.g. site meets safety requirements and minimum economic feasibility).
4. Licensing and institutional aspects.
5. Forecasted demand.

Six NGV companies are now licensed to operate in Egypt, providing conversion and maintenance services as well as building refueling stations. The shareholders in those companies have existing and well established activities in the gas industry in particular or in the petroleum industry in general. The synergies attained in the collected expertise along the levels of the industry will sure be a driving factor to balance the supply side of the market.

Supply side barriers however will include:-

1. Permitting process for constructing refueling stations. MOP and EGAS however have done a great effort in overcoming such barriers through a Cabinet decree.
2. Refueling stations network barriers associated with the coverage of the natural gas grid.
3. High investment cost of constructing refueling stations.

Although there is a well established natural gas infrastructure that delivers natural gas to many urban and suburban areas all over the country, some key geographic areas are not covered to date including Upper Egypt, North and South Sinai, Red Sea cities, Matrooh, and Wadi El Gadid. The existing infrastructure however provides for an adequate CNG fueling stations network at the industry's current stage of development.

E. MARKET INCENTIVES

The insertion of creative incentives among the public will help in defeating barriers in this stage of development.

Development initiatives include the introduction of the "Gas Card" program which is a micro credit policy arrangement by the Commercial International Bank (CIB), which provides 100% financing to vehicle owners to convert to natural gas. Under this program, the bank would collect the loan repayment through a higher sales price of natural gas collected and registered electronically by refueling stations.

Restructuring the fuel price policies will adopt the expected CNG price spread program. However such policies are subject to Egypt's social and political policies.

Another incentive is the CNG price advantage over gasoline as set by the fuel tax policy. Still the private owned vehicles segment remains to be a challenge. We should identify what incentives and benefits to offer the private vehicle owners by carefully identifying usage habits and attitudes of private car owners in Egypt.

Surveys need to be regularly conducted to solve problems as they occur. In addition, focused efforts on public awareness and addressing misperceptions must also be adopted in the coming period.

IV. ADVANCING FROM A DEVELOPING TO A SUSTAINED INDUSTRY

A. TECHNICAL FEASIBILITY AND CONCERNS BY THE PUBLIC

The 3 types of engine technologies that can operate on CNG are bi-fuel, dual-fuel, and dedicated CNG engines. Bi-fuel systems are used to convert gasoline-operated engines where either CNG or gasoline can be used to operate the vehicle. Dual-fuel systems are used to convert diesel-operated engines. For those systems, either CNG and diesel or diesel only can be used for the operation. Dedicated CNG engines are designed to solely operate on CNG.

The current local expertise in conversion of gasoline-operated vehicles to bi-fuel systems revealed several technical and operational concerns:-

1. Minimum requirement for engine efficiency before the conversion.
2. Shorter range of travel.
3. Extra load and space concerns.
4. Technical problems resulting from the tremendous increase of vehicle technologies versus CNG technologies.
5. Limited OEM participation of conversion of vehicles.

There has been no conversion of diesel to CNG in the market due to:-

1. High cost of diesel conversion.
2. The price advantage of diesel fuel.
3. Technical disadvantages associated with the conversion.

Perceived technical problems, whether based on real observations or mere misperceptions, will greatly influence the conversion decision. Raising the quality of the conversion and the continued correct maintenance at specialized centers will assure control over many technical issues.

B.FINANCIAL FEASIBILITY OF PROJECTS

Like any project, CNG fueling stations are studied carefully since they involve substantial capital commitments and opportunity costs. A CNG company is faced with a dilemma of expansion and geographical coverage against economic returns from refueling stations and conversion centers.

The average CNG refueling station realizes a payback on initial investment in 5-7 years. The internal rate of return in such projects ranges from 15-17%. The optimal cost for an average size/capacity refueling station is EGP 6-7 million excluding the potential cost of purchasing the land, which is not the usual case, since most CNG stations are established on leased or rented land and in the presence of a commission on sales agreement.

When evaluating the possibility of constructing a CNG station in a specific site, a preliminary feasibility should be conducted and incorporating factors mainly associated with the site itself. This would include the capacity that could be delivered by establishing a CNG facility along with the proposed station layout suitable for the site's parameters. Another primary evaluation would be to the safety of the site's surrounding as set by the industry's standards. A preliminary estimate of cubic meter sales would also be done. This study would be done exclusively from the project's view and not from the company's view as a whole.

After filtering out unsuitable sites the second step would be to evaluate possible agreement scenarios and their effect on the selection of the most suitable site(s) along with preparing a comprehensive feasibility study over the life of the projects. At this stage all costs associated with constructing and running the stations are estimated thoroughly to aid decision making on the section of the site. Such measure however should carefully be administered in light of the company's objectives. In many cases, a CNG company is willing to construct a refueling station or a conversion center knowing that financial returns are somehow limited by external factors, for example; farness from the natural gas grid or from

conventional utilities. In such cases, companies usually have objectives of expansion and antecedence in certain areas to gain customer loyalty and induce car conversions in newly penetrated regions.

In cities however, it is important at this stage to estimate only the incremental sales a new constructed station would bring to the company as a whole, i.e. the opportunity cost of surrounding company stations would be incorporated in the study. This comprehensive study, done from the total company view, should prioritize investments in stations evaluating the added value to the company as a whole considering limits set by capital expenditure budgets for the concerned periods.