

Gas Utilisation Opportunities in the Existing Market and The New Approach In Developing of Combined Heat and Power (CHP); The Significant Unique Features of Natural Gas.

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Abstract

Natural gas with its 'green properties' is being widely used in various aspects especially in the application of heating process because of its secured supply compared to other fossil fuel options. In context of Malaysia's approach, the vision of 2020 of developing to an industrial country, natural gas must be seen as one of the important commodities for internal and external economic development.

Introduction

The gas utilization opportunities can be seen in three market classifications - industrial, commercial and domestic sectors. All the market sectors have their own specifications.

The industrial sector is the manufacturing industries with large, sophisticated and wide range of processes. These include food, breweries, tobacco, chemical paints, synthetic resins, pharmaceuticals, ferrous metals, mechanical and marine engineering, electrical machinery, vehicles, aircraft, metal goods, synthetic fibres, textiles, leather (clothing), heavy clay (bricks), pottery, glass, cement, building materials, mining (quarrying), paper manufacturing, printing and rubber.

The commercial sector can be seen as industries of transport, wholesale and retail distribution, insurance, banks, other business services, scientific services, religious organisations, educational services, hospitals, entertainment, hotels and residential establishments, catering and bars (including clubs), laundry outlets, national and local governments.

Domestic sector is the use of in house appliances for new and existing housing.

The commercial and domestic sectors have always faced competition from electricity appliances. But the choice between the two depends on both cost and operating expenses.

With the new approach and development of Combined heat and power (CHP), the gas utilization opportunities have widely expanded in the various sectors.

The related data given in this paper were taken from the British Data.

Demand for Natural Gas

The gas consumption is expected to grow faster than of all other fuels, particularly due to environmental concerns with coal, nuclear energy, and hydropower, especially in developing countries for development of urbanization, industrialization, and transportation. The expectation of 14 per cent of growth to over 20 per cent by the year 2000 has involved the sharing of gas consumption in total commercial energy consumption.

Table 1 shows that the power generation sector gives a good market for natural gas in developing countries compared to other sectors. However the other sectors also have the good potential for natural gas to penetrate especially in industrial and residential/commercial areas. All the potential markets can be seen what is happening in gas utilization developments and opportunities, example in United Kingdom. The combined heat and power (CHP) is recognised as the new developing technology for the next decade for industrial and commercial uses, so there are the market opportunities for gas utilization technology.

Table 1: Sectoral Distribution of Natural Gas (%)

Category	Industrial	Power Generation	Residential/Commercial	Raw Material	Total
World	28.0	40.0	26.0	6.0	100
Developing countries:					
Latin America	36.5	47.5	9.5	6.5	100
Africa	12.5	80.5	3.5	3.5	100
Asia	31.5	38.5	8.5	21.5	100
Middle East	25.0	60.0	6.0	9.0	100

Industrial Gas Market

Industrial gas application can be classified as low temperature (below 500°C) and high temperature (above 500°C).

Industrial sector is significantly more complex than residential sector. In this sector there is no single predominantly end-use, but a variety of end-uses. The major categories of energy uses are steam raising, direct heat and chemical uses. The main use is for steam raising in industrial boilers with about 40 per cent of all energy consumed in industry. Direct heat is the second largest use.

In small boiler range particularly in conurbations, gas competes mainly with oil, but for larger boilers gas is also competing with coal, particularly in industrial areas and power generation complexes.

In direct heat sector which includes process heat for drying, baking, firing in ovens/kilns, and heat treating, gas is typically competing with oil products (including LPG).

Energy in the chemical use category is most important in the iron and steel industry, with coke being consumed in the process.

Gas is also used as chemical feedstock for production of methanol, ethylene, polyethylene, urea and fertilizer.

High Temperature Applications (above 500°C)

Natural gas can be used as energy source in high temperature heating processes such as bulk metal melting, cement manufacture, etc. The materials being heated are directly injected with gaseous fuel. Gas-fired furnace and kiln designs have developed rapidly resulting mainly due to the application of scientific principles, the availability of new burner systems and the extensive use of jet-driven recirculation.

High temperature furnaces are inherently inefficient. For example a gas-fired furnace operating at 950°C, loses about 50 per cent of its heat input in the heat content of its combustion products, but this loss will be higher with excess combustion air.

A large part of this loss may be recovered by air preheating or continuous furnaces by load preheating. The use of separate heat recovery devices (recuperative, heat wheel etc.) and the gas burners with integral heat recovery (recuperator and regenerative) have increased along with fuel prices.

Low Temperature Applications (below 500°C)

Steam raising is the major application where gas is used for firing in a wide variety of boiler types. The steam generated in industrial boilers is used to heat liquids in vats, tanks and etc. Steam with its flexibility and high heat content per unit volume is a convenient medium for the purpose, however the overall efficiency is very low.

The Combined Heat and Power (CHP) are ideally suited for industries in which energy requirement are steady all year demand. Steam turbines in CHP were widely used as prime movers with low generating efficiencies and high heat/power ratio. With new CHP technology, new high efficiency steam turbines or large reciprocating engines is obtained by using gas turbines.

What is the Combined Heat and Power (CHP) ?

It is like electricity generation where the waste heat can be fully used in buildings or industrial processes. This new technology consists of reciprocating engines and gas turbines, necessary control equipment, heat recovery devices and other ancillaries. The waste heat is available to produce either hot water or steam which is suitable for both building and industrial process heating loads. The ideal fuel for CHP is undoubtedly natural gas with its several advantages especially for economic and environmental approaches as well as the high reliability of supply.

CHP provides opportunities as follows;

1. to reduce energy costs
2. to increase the market for the gas industry
3. to increase equipment sales for CHP industry
4. to reduce emissions for the benefits of the environment
5. to extend fossil fuels reserves.

The market opportunities of the CHP installation can be seen in three areas;

- ☐ large scale CHP
- ☐ small scale CHP
- ☐ combined cycle power generation.

Large Scale CHP (over 0.5 MW)

This CHP scale is largely used for industrial and commercial energy users based on gas turbines and heavy duty reciprocating engines. Industrial organisation such as chemical, textile, paper, food and brewing have claimed that CHP has reduced the total fuel cost, flexibility of operation and improved energy efficiency. The overall plant efficiency is about 90 per cent. Other applications are pharmaceutical, medical, agriculture, educational establishment, production and marketing of water soluble polymers, biodegradable chemical agrochemicals, and commercial buildings. In some applications, the virtual absence of sulphur in natural gas means that it is possible to utilize the exhaust waste heat in direct contact with product, example, in drying process.

Small Scale CHP (under 0.5 MW)

A gas-fired CHP units have been installed in commercial premises. Currently, small scale CHP units are used with success in swimming pools, leisure centres, hotels, hospitals and sheltered homes, health service centre and high standard of comfort and service.

Recovered heat can also be used in an absorption chiller to produce chilled water for air conditioning in offices, retail stores and computer switches.

Combined Cycle CHP

The main objective is primarily to generate electricity. Recently the most popular generating power has utilized the 100 MW plus gas turbine, a heat recovery boiler and a steam turbine generating set, giving a total output of 350-450 MW with an overall efficiency about 50 per cent.

In UK market for the next five years, it is anticipated that 12,000 MW of gas turbine combined cycle power plant will be operated. This will be involving the construction of 25 power stations with block modules in the 350 MW to 450 MW range.

Commercial Gas Market

The commercial market is to service industries such as government departments, hospitals, retail shops, local authorities, municipal buildings and etc., as diverse as a small shop and a modern low energy hospital complex. The main energy requirements are for space heating, cooling, catering, refrigeration, hot water, lighting and office equipments. Catering is the potential future market. Table 2 shows the commercial market energy profile in UK (1985). The service sector is subdivided into the private and public sectors and both have grown steadily especially in UK.

Table 2 : The commercial market energy profile in UK (1985).

<u>Product Groups</u>	<u>%</u>
Space heating	60
Lighting	10
Water heating	8
Catering	8
Other (including air conditioning)	14

Gas in this market has a number of advantages over competitive fuels, in particular its flexibility, low pollutant emissions and the absence of storage requirements. The traditional gas markets in the commercial sector have been space and water heating together with a small requirement for catering.

The conventional method uses low pressure hot water from a centralised boiler has been applied for space heating where three broad types of boiler are in use. Traditional practice is to provide hot water from a cylinders indirectly heated by boilers which are also used for space heating.

Offices, insurance and banking use the energy for space heating and lighting. However the new and refurbished buildings have considerably higher heating requirements due to the introduction of air conditioning and office machinery in comparison for old buildings.

Gas and electricity are the dominant fuels in large retail stores and supermarkets due mainly to the very high refrigeration and lighting requirements.

The health sector comprising of hospitals, health centres, nursing homes, surgeries and staff accommodation. Laundry facilities and catering systems are being centralised as one large production kitchen which incorporate more energy efficiency. The introduction of low pressure hot water systems has been a productive market for gas for supplying humidification plant and sterilisation equipments.

For hotel sector, about 60 per cent of the energy consumed is for space and water heating, usually provided by central boiler systems and over 85 per cent of hotels use gas for cooling.

Catering sector, the public sector and in contract catering there has been more towards large centralised production kitchens using cook/chill systems supplying a number of satellite units. There is still a traditional system using steaming and boiling techniques on gas burning equipment but is reducing in popularity.

In educational buildings (schools, universities and colleges) about 90 per cent of the total energy used is used for space heating, water heating and catering.

Other sectors such as sport centres, swimming pools and museums use gas for space heating.

Gas penetration into the air conditioning market is very new in order to eliminate the use of CFCs due to environmental factor.

Combined heat and power (CHP) is widely used to derive the production of heat from energy sources.

Domestic Gas Market

Gas appliances have very strong competition with electricity appliances, especially refrigeration, laundry and dehumidification. The choice between the two will have to be made on the strength both of cost and operating expenses. To domestic small consumer, gas has the great advantage of being supplied by pipe into the home without the need of fuels delivery, storage and payment in advance of utilisation.

Table 3 shows the sharing of domestic gas sales by product groups in UK (1986). It is also shown that central heating is very much the dominant factor, so there is a greater potential for increase sale of gas central heating. To get a satisfaction of usage, it is advisable to install a complete central heating package. However the gas demand for this sector will be varied according to the seasonal variations especially winter seasonal. This factor does not apply to those tropical or warm countries. The district supply will have to involve private organisation and local authority.

Table 3 : Share of Domestic Gas Sales by Product Groups (1986 British Gas)

<u>Product Groups</u>	<u>% Sharing</u>
Fires	16
Wall heaters	7
Water heaters	4
Cooking	5
Central heating	68

Central heating systems use a wide range of boiler units and controls for varying applications. The gas sales involved new and existing domestic customers in which the current sales of gas boilers are evenly divided between those installed new systems and those replacing old central heating appliances. The latter are associated with kitchen modernization, however the installation central heating facilities are costly.

The use of gas in central heating has competed with gasoil, so there is a reasonable prices relatively large quantities consumed per household or per apartment building per unit gas suppliers.

In UK, space heater or gas fire is probably the fastest changing product in the gas appliance range and the market for individual space heaters has also been steadily evolving. Thus, technically advanced products designed for ease of installation in modern housing have been developed.

The space heating sector has a bright market development in the future with a growing boiler replacement market and the installation of gas fires using plastic material. The main competition for individual space heating appliance comes from electricity.

Water heating is unlikely central heating, it is independent of seasonal variation. The water heating load for a typical family is around 180 therms. Furthermore, hot water usage in the house is growing and the growing is coming from new uses of hot water in showers and kitchens appliances.

In the cooling market gas has always faced with competition of electricity and this has increased with the development of microwave ovens and halogen hot plates.

The Significant Unique Features of Natural gas comparing to Coal and Fuel Oil. Technical Advantages

Heat Treatment Process :

The competitiveness of natural gas in comparisons to other fuels (coal and fuel oil) depends on the way they are used. Example in heat treatment process, how the effectiveness can be achieved from these fossil fuels either direct or indirect firing in low and higher temperature.

Natural gas with its negligible content of sulphur, has the cleanliness and purity, leads to marked advantages in quality of product in the heat treatment and metaal reheating process. These are also applied in process such as drying, curing where direct firing can be employed in which the material being heated can be directly contacted with the combustion gases, leading to substantial improvements in heat transfer rates and efficiency and lower capital cost compared to indirect methods.

When indirect heating has to be employed for example in boiler equipment, there is an absence of fouling and low temperature corrosion on heat exchanger surfaces. This will give higher efficiencies which do not quickly deteriorate in performance.

In contrast, coal and heavy fuel as indirectly have disadvantages of low efficiency, slow in heating up, inflexibility of contact, not easy to occur combustion etc.

Controllability :

As fluids, natural gas is easy to control by pressure and is controlled relatively by simple governors and throughputs controlled by a variety of valves which can be actuated by electric, pneumatic or hydraulic system.

In comparing to other fuel particularly solid fuels, air/fuel ratio control equipment can be fitted with less expense, giving higher efficiencies than with simple on/off control.

Natural gas is better controllable than other fuels and thus reduce the maintenance and operating cost (reduced manpower and electricity needed).

During combustion, example in combined cycle power plant, there is a possibility of quite combustion, easy automation of integrated firing and has a flexibility of firing conditions.

Direct Piped Supply :

Burner equipments can be securely supplied by direct pipeline, means that

- no on-site storage is needed
- no delivery problems
- no ordering is needed, supply is continuous
- distribution around a factory or other premises is easy and inexpensive

Environmental Impact

Air pollution and acid rain are two major environmental problems caused largely by burning fuels. Coal is the worst source, followed by oil and then natural gas. Recently carbon dioxide emissions from man-activities has caused the greenhouse effect and changed the earth's climate. The sea level has risen due to global warming. Thus it is important to reduce the contribution of carbon dioxide emission into the atmosphere. Table 4 shows that the power generation has contributed about 11 per cent of total 55 per cent carbon dioxide in greenhouse gases.

Table 4 : Relative Contributions to carbon dioxide.

Carbon dioxide

55 %	Electricity	11
	Reforestation	15
	Other energy	29

Other gases

45 %	Hydrocarbons	20
	CFCs	15
	Nitrous oxide	5
	Ozone	5

The electricity generations come from the existing coal-fired power plant. It is proven that natural gas as the burning fuel for power generation can reduce the carbon dioxide contribution into the atmosphere. Natural gas has been always considered as a clean gaseous emissions. It can be used as a fuel for gas turbines or certain type of internal combustion engine. With its 'green' properties and virtually no impurities, can help to control and produce the low pollutant emissions especially the concentration level of carbon dioxide into the atmosphere when it is burned. Table 5 shows the relative carbon dioxide emissions per unit of heat released.

Table 5 : Relative carbon dioxide emissions per unit of heat released.

	<u>%</u>
Coal	100
Oil	82
Natural gas	56

A new concept of gas turbines combined cycle power plant is being introduced for the next decade in which natural gas is used as the energy source. By introducing natural gas into the new and existing coal-fired power plant, the combined cycle power plant can increase its efficiency. It has been proved that by using the gas turbines, carbon dioxide emissions may be reduced by about 55 per cent compared the similar size of coal-fired power plant. Table 6 shows the attributes of fossil fuels with merit and demerits.

Table 6 : Attributes of fossil fuels with merits and demerits.

Coal	-	vast reserves worldwide
	-	price is likely stable for long term
	-	diversity of supply
	-	low cost reserves that exist
	-	reserves are low sulphur and higher sulphur
	-	flue gas desulphurization but expensive
	-	carbon dioxide production is high
Oil	-	high availability
	-	price is likely to be volatile
	-	high demand but severe price effect
	-	carbon dioxide is high
Gas	-	high grade fuel
	-	environment attractive
	-	abundant in supply
	-	sell in the final and conversion markets
	-	long term contract.

In power generation using combined cycle power plant, again natural gas has proved that as long as its supply is available, the plant has output as follows;

- high efficiency
- speed of construction
- low capital cost
- low pollutant levels.

Impacts of Non-Fossil Energy Option.

Electrical power can be generated by primary energy such as gas, coal and heavy oil. It is also produced by other non-fossil energy option of nuclear and hydropower sources. However the last two sources will have other impact to the environment.

Safety and long-term storage of nuclear waste are the two principles to be concerned when nuclear source is used to produce power. Anti-nuclear development has been changing dramatically.

Hydropower sources are cheap and clean energy, however the sources are being reconsidered throughout the world;

- * massive and destructive relocation of communities
- * destroy flora and fauna
- * weight of the reservoir can cause geological disturbance
- * increase in water borne diseases
- * lower the water table.

Natural Gas Reserves

Some of 47 per cent of global proven gas resources of 111.7 trillion cubic meters are located in 57 developing countries means that opportunities for gas development and this gas reserves exceed the proven oil reserves.

Table 7 : Gas Reserves by Regional (Trillion cubic meters)

<u>Major Regional</u>	<u>1980</u>	<u>1985</u>	<u>1988</u>
Developing countries	31.6	41.7	52.1
Latin America	4.4	5.4	7.1
Africa	5.6	5.9	7.2
Middle East	17.9	25.0	30.2
Total World	76.9	96.4	111.7

By the proven gas reserves, many countries have more confidence about energy security after the oil first and second crises.

The Power of Natural Gas in CHP.

Besides the environmental advantages of its cleanliness and consistent quality, it offers more reliable, efficient operation, longer plant life and reduced maintenance. Delivery and storage problems are eliminated as the gas is piped directly to site ready for use when required. It generates lower cost even any additional overheads. However the running hours must be in excess of 4,500 hours a year then it is possible to have significant cost savings and also provide useful income which reduces total energy costs. To build a CHP is costly but the financial savings from reduced electricity costs are attractive payback periods and reduced energy costs in future periods.

Conclusion

The gas utilisation opportunities of natural gas can be classified as industrial, commercial and domestic sectors.

The use of natural gas for the three markets are obviously increased with the technology development especially in Combined Heat and Power (CHP).

There are several significant unique features of natural gas as mentioned above in comparison to other fossil fuels.

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