COAL SYNTHESIS GAS : A SUBSTITUTION OF NATURAL GAS IN BANGLADESH

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ABSTRACT

Energy is one of the most important factors for a developing country like Bangladesh. Like the rest of the countries of the world, the demand for energy is increasing day by day in our country. Energy sector of Bangladesh is exceedingly depended on the limited gas reserve. Given the rising demand for fuel it will be very difficult t to meat this demand with only indigenous natural gas. About 80% of the power generation in the country is now gas based. Therefore diversification of fuel has become indispensible it has been envision 2021 that 53% of the power generation will be coal based by year 2021. The worldwide scenario shows that, Coal is the ultimate fuel for future. Bangladesh is very lucky that it has got significant but almost untapped high quality coal resource. Five coal fields in the country contain 3.3 billion metric tons coal. Recently rate of coal production from Barapukuria are increased significantly due to application of modern coal extracting method, LTCC. Coal to Synthesis gas conversion, is an emerging technology to wide the application area of coal and commercially proved technology worldwide. The paper gives an overview of the current state of coal scenario and natural gas scenario in Bangladesh. Here we discuss the principles of coal to syngas conversion technology and aside from a brief introduction to 5 process methods for conversion of coal to Synthesis Natural Gas (SNG). The Steam-Oxygen Gasification, Hydrogasification, Catalytic Steam Gasification, Underground Steam-Oxygen Gasification, Underground Hydrogasification processes are discussed with the help of process flow diagram. This paper also summaries the present scenario of Syngas production worldwide. Finally we propose a coal based syngas infrastructure, where coal is converted to syngas, then processed to make Synthesis Natural Gas (SNG), then it transmitted via dedicated pipeline or injected into existing natural gas pipeline to the different types of user like Household, Thermal Power Plant, Brick Field, Ceramics & Glass Industry and any kind of thermal process industry. This proposed technology is design to reduce the dependency on natural gas.

KEYWORDS

Coal, Coal gasification, Synthesis Gas, SNG, Bangladesh, Substitution of Natural Gas

1. INTRODUCTION

Gas is a well known energy carrier. It is often used for producing heat and power, but can also be applied as a fuel in the transport sector. Other side, coal has been the fuel most used for thermal energy since the early days of the industrial revolution. However, the mechanization of factories quickly brought a shift in coal use from heat to steam engines, and then to fuel steam turbines to power the electric motors of industry. The worldwide energy scenario shows that, coal is the ultimate fuel for future, [1]. Natural gas is the most important fuel for Bangladesh – both in terms of energy and diversity of use. Bangladesh, the seventh largest natural gas producer in Asia in 2012, produced 772 billion cubic feet, all of which was domestically consumed. Natural gas production in Bangladesh has increased by an annual average of 7% over the past decade, from

2002 to 2012. However, Bangladesh is facing acute natural gas supply shortages especially in the electricity sector. These shortages, in turn, have led to rolling blackouts of electricity. According to Report of U.S. Energy Information Administration (EIA), Platts estimates that Bangladesh must increase its natural gas supply by at least 18% to eliminate natural gas supply shortages, [2]. This paper gives an overview of the current state of coal scenario and natural gas scenario in Bangladesh.

Coal gasification offers one of the most versatile and clean ways to convert coal into gas, hydrogen, and other valuable energy products. The production of synthetic natural gas (SNG) from coal is an interesting opportunity for both exploiting coal and biomass, and for replacing oil products for transportation and other uses. Nowadays, the rise of natural gas prices have created a strong interest in producing SNG from the cheaper and much more abundant coal. A renewed interest in basing more energy consumption on coal and petcoke has resulted in a revival of several older technologies that have been enhanced to improve efficiency and to lower investment cost. The paper discusses the principles of coal to syngas conversion technology and aside from a brief introduction to 5 process methods for conversion of coal to Synthesis Natural Gas (SNG). This paper also summaries the present scenario of Syngas production worldwide.

SNG has many important advantages with respect to other synfuels: it can be transported efficiently and cheaply using existing natural gas pipelines and distributing networks, it is an easily convertible feedstock, both in natural-gas combined-cycle power plants and in petrochemical facilities, it can count on a high social acceptance with respect to coal, and it can be stored underground, enabling efficient operation throughout the year independently of a fluctuating demand. This paper also summaries the present worldwide scenario of Syngas production from different types of feedstock like, coal, biomass, wood, waste, etc. Finally we propose a coal based syngas infrastructure for Bangladesh. In this infrastructure coal is converted to syngas in a central gasification plant, then it purified through purification plant, then processed to make Synthesis Natural Gas (SNG), then it transmitted via dedicated pipeline or injected into existing natural gas pipeline to the different types of user like Household, Thermal Power Plant, Brick Field, Ceramics & Glass Industry and any kind of thermal process industry. This proposed technology will reduce the dependency on natural gas and help to build a sustainable energy plan for future.

2. COAL SCENARIO IN BANGLADESH

Bangladesh is very lucky that it has got substantial natural gas reserve and significant but almost untapped high quality coal resource. There is also plenty of scope to generate solar power, wind power and energy from bio fuels. Many countries of the world like Japan, Korea do not have any fossil fuel resource yet they are among the top developed nations. They import almost their entire requirement of the fuel for energy generation from highly competitive energy market. Several countries do not have enough basic fuel to meet their huge demand. These countries import energy from energy rich countries to fuel their economy.

Unfortunately, our small country Bangladesh of 160 million people has no appropriate strategy. There is an energy policy, which is not properly administered. Till date five major coalfields have been discovered in Bangladesh. In order of discovery year these are Jamalganj (1962), Barapukuria (1985), Khalashpir (1989), Dighipara(1995) and Phulbari (1998). At present coal is being produced commercially only from the Barapukuria underground coal mine in Dinajpur district that has gone through a period of 8 years of construction and one year of production. Current production rate is about 1500 tons per day. The plan to establish an open-pit mine in nearby Phulbari was aborted last year in the wake of mass protest by the local people. Coal in the Jamalganj-Paharpur area is too deep to mine. Most of the energy experts believe that there is no option for Bangladesh other than mining its coal for power generation, because the future power demand cannot be meet from gas-based power plants, as the gas reserve is too limited to run for long. At present, the only coal-based power plant (250MW) in the country is in operation near Barapukuria coalmine, which feeds the plant. If the Barapukuria mine runs efficiently for its expected lifespan and if feasibility studies conducted at other fields conclude positively only then we can expect that the contribution of coal in the total energy mix in the country will increase in future.

TABLE 1. MAJOR COAL FIELDS AND PROVED COAL RESERVES IN BANGLADESH

Coal field (district)	Year of discovery	Discovered by	Depths of coal seam (meter)	No. of coal seam	Reserve (million ton)	Status
Jamalganj (Joypurhat)	1962	SVOC	640-1158	7	1053	Mining not feasible economically
Barapukuria (Dinajpur)	1985	GSB	118-506	6	303	Underground mine started production
Khalashpir (Rangpur)	1989	GSB	257-451	8	147	Undeveloped
Dighipara (Dinajpur)	1995	GSB	250	7	200	Undeveloped
Phulbari (Dinajpur)	1997	BHP	152-246	1	380	Open pit mine feasibility study undertaken in 2004

**Source Petrobangla; Geological Survey of Bangladesh

3. NATURAL GAS SCENARIO IN BANGLADESH

Bangladesh has energy supply especially from fossil fuel sources and a less extent of, renewable sources. However, almost 70 percent of commercial energy is provided from natural gas. Currently, the country is suffering from a shortage of 500MMCF gas production per day. Natural gas has become the prime fuel source for electricity generation in Bangladesh. But electricity sector is not only the sector that are demanding natural gas as a fuel but, other existing sectors like fertilizer, industry, transport and residential sectors are also in need of it. This indicates the foundation of national economy is dependent on natural gas in many ways. Hence a condense analysis on the reserve, availability and proper use of natural gas need to be conducted before escalating new gas consumers.

A conservative estimate of sector wise allocation of gas (in Billion cubic feet) is shown below. This table indicates the demand for natural gas is in every sector while, power sector is the dominant participant. At present, it has been a common scenario that many publicly owned power plants are suffering from outage because of the insufficient fuel supply. In the year 2011, the Power Development Board (PDB) had to suspend operation of a huge number of its generation units having a total of 700-MW production capacity on account of gas shortages [3]. Moreover, exploring and discovering gas is a capital intensive and risky investment. It needs an investment of approximately BDT 700 core for discovering a gas field, whereas the rate of success is only 20-25 percent [4].

Petrobangla chairman Dr. Hussain claimed the following about the gas crisis in the country, “During the last three years gas production capacity has increased by 505 MMCFD while, actual production was raised by 320 MMCFD. During the same period, production at different gas fields has reduced by 185 MMCFD for obvious reasons. He projected that the country′s demand for gas will go up to 3,043 million cubic feet per day (MMCFD) by July 2012 and 3,341 MMCFD by July 2013 from the present demand of 2,500. At present, the highest total gas production is 2067.4 MMCFD from 18 gas fields while shortage is more than 436 MMCFD. The country′s power sector operators not to be hopeful of getting adequate gas supply to feed their power plants planned to be installed by 2015." [5].

The natural gas consuming sectors in Bangladesh are Power, Fertilizer, Industry, Captive power, Domestic, Commercial and Transportation. Present Sector-wise Gas Consumption Presently 2330 mmscfd gas is being consumed by power (41%), Fertilizer (7%), Industry & Tea-Estate (17%), Captive Power (17%), CNG (5%), Commercial (01%), & Domestic (12%) sectors. About 2.5 million customers of different sectors presently used natural gas in the country. There are 72 gas based power plants in the country. Out of them 31 grid connected and 5 non-grid power plants having total capacity of more than 2300 MW has been installed in the last 5 years. These newly connected power plants accounts for 40% of the gas supply to the power sector. Because the increasing demand for natural gas (methane) in the Bangladesh and the limited domestic supply, foreign natural gas need to import or alternative of natural gas has to be manage.

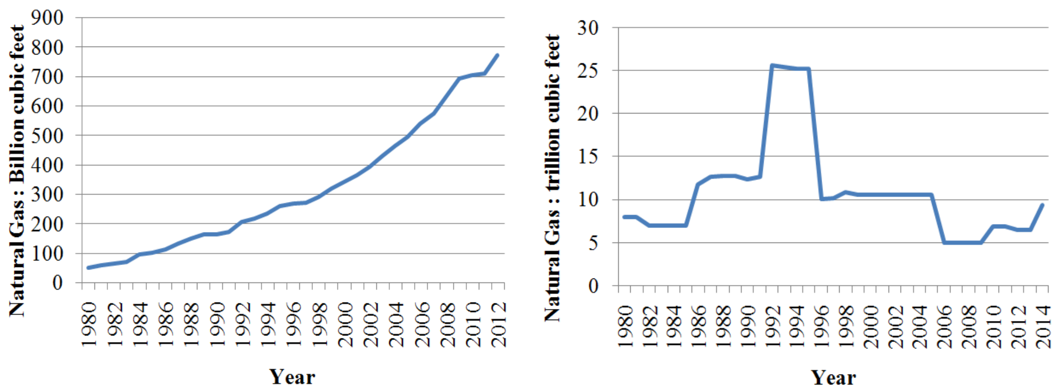

Fig -1: a) Bangladesh natural gas consumption (1980-2012), b) Bangladesh natural gas proved reserves, [2]

4. COAL TO SYNTHESIS GAS

The Gasification process make possible to separate the good parts from the bad, and select the parts you want to keep. Gasification avoids burning coal altogether: it turns coal into gas. One of the major environmental opportunities of this technology is the fact that impurities can be almost entirely filtered out when coal is transformed from a sold into a gas, alleviating many of the environmental concerns of coal-fired power plants. In fact, gasifying coal is one of the best ways to clean pollutants out of coal, and many experts predict that coal gasification will be the heart of clean coal technology for the next several decades.

In a gasifier, the carbonaceous material undergoes several different processes:

1. The dehydration or drying process occurs at around 100°C. Typically the resulting steam is mixed into the gas flow and may be involved with subsequent chemical reactions, notably the water-gas reaction if the temperature is sufficiently high enough.

2. The pyrolysis process occurs at around 200-300°C. Volatiles are released and char is produced, resulting in up to 70% weight loss for coal. The process is dependent on the properties of the carbonaceous material and determines the structure and composition of the char, which will then undergo gasification reactions.

3. The combustion process occurs as the volatile products and some of the char reacts with oxygen to primarily form carbon dioxide and small amounts of carbon monoxide, which provides heat for the subsequent gasification reactions. Letting C represent a carbon-containing organic compound, the basic reaction here is, $C+O_2 \rightarrow CO_2$

4. The gasification process occurs as the char reacts with carbon and steam to produce carbon monoxide and hydrogen, via the reaction, $C+H_2O \rightarrow H_2+CO$

5. In addition, the reversible gas phase water-gas shift reaction reaches equilibrium very fast at the temperatures in a gasifier. This balances the concentrations of carbon monoxide, steam, carbon dioxide and hydrogen. $CO+H_2O \leftrightarrow H_2+CO_2$

Table 2. Percent o Component Produced In Coal Gasification Process, [6-8]

Main Components		**Harmful Substance & contaminants**	
H_2	25 – 30 Vol.%	H_2S	0.2 – 1 Vol.%
CO	30 – 60 Vol.%	COS	0 – 0.1 Vol.%
CO_2	5 – 15 Vol.%	N_2O	0.5 – 4 Vol.%
H_2O	2 – 30 Vol.%	Ar	0.2 – 1 Vol.%
CH_4	0 – 5 Vol.%	NH_3 + HCN	0 – 0.3 Vol.%

By using gasification process, we can produce synthesis natural gas (SNG). The principle of catalytic synthetic production of methane from carbon monoxide and hydrogen was discovered in 1902 by Sabatier and Senderens [9]. It is described by the CO methanation reaction:

$CO+ 3H_2 \leftrightarrow CH_4+H_2O$ …………..…. (1)

Carbon dioxide can also be converted to methane according to the following reaction

$CO2 + 4H_2 \leftrightarrow CH_4+2H_2O$ ………….. (2)

Both reactions are linked by the water gas shift conversion, which is always observed simultaneously whenever active catalysts are used:

$CO +H_2O \leftrightarrow CO_2+H_2$ ………………… (3)

A number of observations, reported in [9], indicate that the transformation of carbon dioxide to methane is initiated by a reverse shift conversion reaction with hydrogen to yield carbon monoxide and steam. The carbon monoxide formed then reacts to yield methane. Both reactions (1) and (2) are strongly exothermic: -206kJ/mol and -165kJ/mol, respectively. Also low temperature and high pressure are required to achieve high methane yield. Interest in SNG production is concentrated on the gasification step, which may yield high methane content in the raw gas. This is possible, for instance, with Lurgi pressure gasification of coal, especially when gasification pressures of 80-100 bar are applied, as has been successfully tested in recent years [9]. Methanation processes with little methane in the raw syngas suffer principally from:

1. High exothermic heat release during methanation;
2. Need of handling very large quantities of synthesis gas (four to five volumes of dry synthesis gas yield one volume of methane);
3. High proportion of steam formed during methane synthesis, which limits the directly achievable SNG quality in wet methanation steps.

There are at least 5 process methods for conversion of coal to SNG.

1. Steam-Oxygen Gasification
2. Hydrogasification
3. Catalytic Steam Gasification
4. Underground Steam-Oxygen Gasification
5. Underground Hydrogasification

4.1. Steam-Oxygen Gasification

In the steam-oxygen process of converting coal to SNG, coal is gasified with steam and oxygen. The gasification process produces carbon monoxide (CO), hydrogen (H2), carbon dioxide (CO_2), methane (CH_4), and higher hydrocarbons such as ethane and propane. The gas composition depends upon the gasifier conditions, i.e., temperature and pressure. At higher temperatures and pressures, the major products are CO and H_2. Three moles of H_2 are required to react with each mole of CO to produce one mole of CH_4. The concentration of H_2 in syngas is increased by a step called the water-gas shift reaction, which is followed by a gas cleaning.

The cleaned gas, consisting primarily of CO and H_2, reacts in the methanation reactor in the presence of a catalyst to produce CH_4 and H_2O. The resulting gas, after H_2O condensation and polishing, if required, is synthetic natural gas (SNG). Figure-2 shows the flow diagram of steam-oxygen gasification. The essential components of the process are the air separation unit, the gasifier, the water-gas shift reactor, syngas cleanup, and the methanation reactor. Each component is described below.

4.1.1. Air Separation Unit :

Oxygen required in the gasifier is either supplied by vendors or generated on-site using an air separation unit (ASU). Cryogenic air separation is the technology generally used in the ASU.

4.1.2. Gasifier :

The most important and basic component of the coal-to-SNG process is the gasifier. The gasifier converts coal into syngas (primarily CO and H_2) using steam and oxygen (O2), generally at a high temperature and under high pressure. As an example, the GE/Texaco gasifier temperature operates at 42 bars and 2,500° F. The different types of gasifiers are: entrained flow, fluidized bed, moving bed, and transport reactor [11]. Commercial gasifier vendors include ConocoPhillips, GE Energy (Chevron-Texaco), Shell-SCGP, Siemens (GSP/Noell), KBR Transport, and Lurgi.

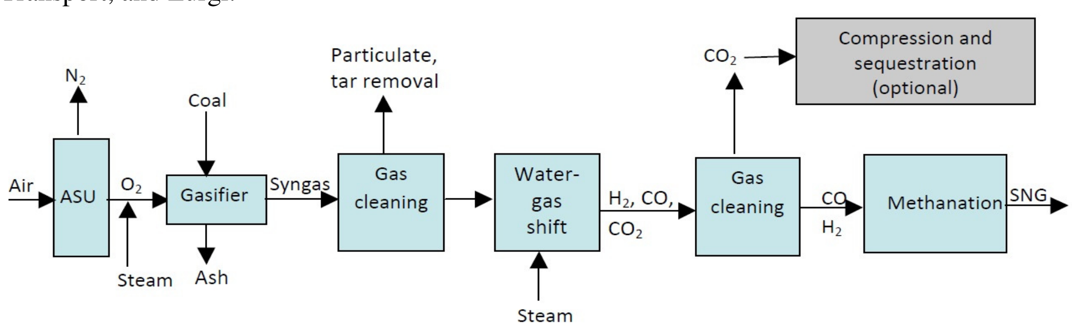

Fig -2 : Steam-oxygen gasification process diagram, [10]

4.1.3. Water-Gas Shift Reactor :

The concentration of H2 is increased by the water-gas shift reaction. In the water-gas shift reaction, CO and H2O are converted to CO2 and H2 in a fixed-bed catalytic converter. The reaction is exothermic and can be completed either before or after the acid gas removal. The catalyst composition varies for both types of shift reactions [12].

4.1.4. Syngas Cleanup :

The syngas cleanup is done in two steps. First, the syngas from the gasifier is quenched and cooled, and the dust and tar carried by the gas are removed. After passing through the water-gas shift reactor, the syngas is cleaned a second time to remove the acid gases H_2S and CO_2. The acid gas cleanup system can use either the Selexol or Rectisol process. Both processes are based on physical absorption, which makes them more economical than the amine process used for CO_2 separation in power plants, which is based on chemical absorption. The processes can be used in a selective manner to produce separate streams of H_2S and CO_2. The H_2S can be further utilized in a Claus plant to generate sulfur. In the Selexol process, a mixture of dimethyl ethers of polyethylene glycol is used as an absorbent. The Selexol solvent absorbs the acid gases from the syngas at relatively high pressure, usually 20 to 138 bars. The acid gases are released using a pressure swing or steam stripping. The Selexol process is more than 35 years old and there are at least 55 commercial units in service [13]. In the Rectisol process, cold methanol is used as an absorbent which absorbs the acid gas at a pressure of 27.6 to 68.9 bars and at a temperature of 100° F. The Great Plains Synfuels Plant uses the Rectisol process.

4.1.5. Methanation :

In the methanation reactor, CO and H_2 are converted to CH_4 and H_2O in a fixed-bed catalytic reactor. Since methanation is a highly exothermic reaction, the increase in temperature is controlled by recycling the product gas or by using a series of reactors. Steam is added to the reaction to avoid coke formation in the reactor. After the steam is removed from the product gases by condensation, SNG is ready for commercial applications.

4.2. Hydrogasification

As the name implies, the hydrogasification process uses H_2 to gasify coal. H_2 reacts with coal to produce CH_4. The hydrogasification process is exothermic in nature. H_2 required for the gasification is either provided by an external source or by using a methane steam reformer. A portion of the CH_4 generated in the hydrogasification reactor is converted into CO and H_2 in the methane steam reformer. The hydrogasification process is in the research stage and is not yet commercialized, although a few studies on the process were conducted from the 1970s to the 1990s. Ruby et al. (2008) have proposed a hydrogasification process which consists of a hydrogasification reactor, desulfurization and carbonizer reactors for CO_2 removal, and a methanation reactor [14]. The advantages of hydrogasification will be discussed in the following section on catalytic steam gasification.

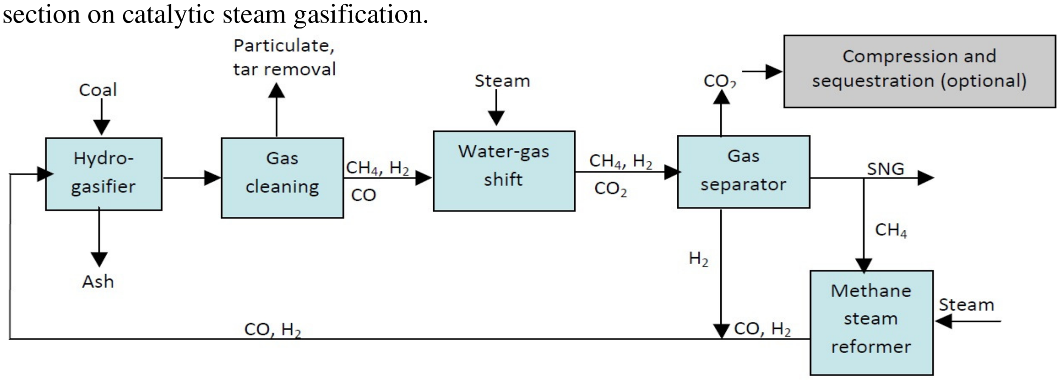

Fig -3: Hydrogasification process diagram, [10]

4.3. Catalytic steam gasification

Catalytic steam gasification is considered to be more energy-efficient than steam-oxygen gasification. However, the process is still under development. In this process, gasification and methanation occur in the same reactor in the presence of a catalyst (Figure-5). The energy required for the gasification reaction is supplied by the exothermic methanation reaction. CH4 is separated from CO_2 and syngas (CO and H_2); the syngas is then recycled to the gasifier. The catalytic reaction can take place at a lower temperature (typically 650°–750° C). The process was initially developed by Exxon in the 1970s using potassium carbonate (K_2CO_3) as a catalyst, but the process was not commercialized.

The advantages of hydrogasification and catalytic steam gasification are that they do not require air separation unit; hence, there is less energy penalty for the process. Furthermore, the costs are lower, as the gasification and methanation occur at a lower temperature. The disadvantages of catalytic steam gasification are the separation of catalyst from ash/slag and the loss of reactivity of the catalyst.

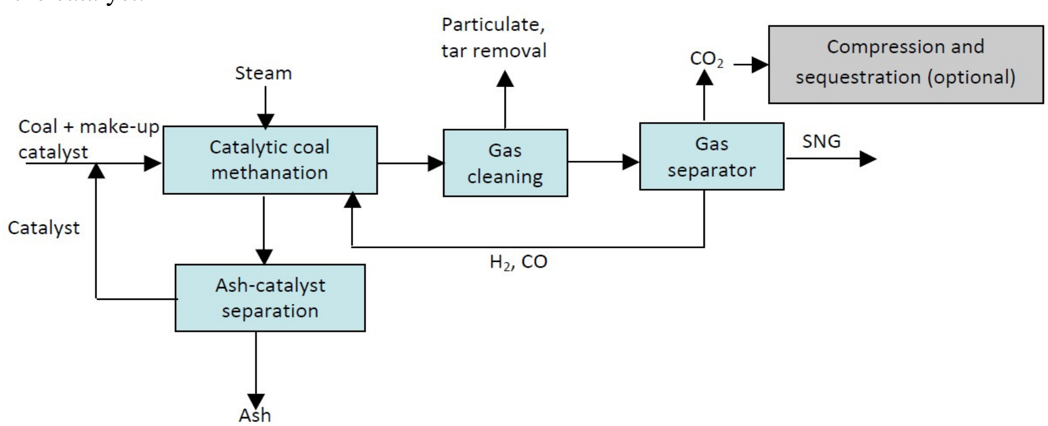

Fig -4: Catalytic steam gasification process diagram, [10]

4.4. Underground Steam-Oxygen Gasification

This process is the same as the above-ground steam-oxygen gasification of coal with the exception that two boreholes are drilled into a coal seam: one is an injection borehole and the other is an extraction borehole. (C.R.F. Probstein and R.E. Hicks, Synthetic Fuels, pp 202-208, pH Press, Cambridge, MA (1990)). Fracturing the coal seam between the boreholes is accomplished by explosives or directional drilling to provide a path for the steam and oxygen between the injection and extraction boreholes. The oxygen permits burning the coal, which creates the temperature and pressure and provides the energy for the steam to endothermically react with the coal in the seam. Oxygen instead of air avoids dilution of the gases with nitrogen.

The gasification reaction produces carbon monoxide and hydrogen synthesis gas. The sulfur and nitrogen in the coal are converted to H_2S and NH_3, which are extracted with the synthesis gas. Above ground, the sulfur and nitrogen compounds and any entrained coal or ash particulates are removed using hot gas cleaning operations. The hydrogen to carbon monoxide ratio in the extracted reaction gas is adjusted by water gas shift to provide a 3 to 1 ratio of hydrogen to carbon monoxide. This ratio is needed to covert the gas to methane in a catalytic methanator. The methane reaction is exothermic and the heat generates steam for the process. The water produced in the methanator is condensed to produce a concentrated substitute natural gas (SNG) product for pipelining. The thermal efficiency for this process is 61.9%, [15].

4.5. Underground Hydrogasification

The underground hydrogasification of coal for SNG production is similar to the above ground process with the exception that the hydrogasification takes place underground. This process is especially useful for unminable coal seams and where methane is produced from coal beddedmethane (CBM) in these seams. The coal seam is accessed by two vertical boreholes spaced a distance apart; one is the intended injection borehole and the other is the intended extraction borehole. A flow connection is then established between the boreholes. This can be accomplished by a number of means, one of which is by horizontal drilling between the holes.

The existing methane resource in the coal seam is removed through the extraction borehole using established coal bedded methane extraction procedures. In this process, the water in the seam is also removed and this is beneficial to the subsequent hydrogasification process. The hydrogasification process then begins with the injection into the coal seam of heated and pressurized hydrogen. Under these conditions, the hydrogen exothermically reacts with the coal, producing methane and carbon monoxide. Some of the nitrogen and sulfur in the coal is converted to ammonia and hydrogen sulfide.

An excess of hydrogen is used to convert the carbon to methane under equilibrium conditions. Two different methods of UCG have evolved, and both are commercially available. The first, based on technology from the former Soviet Union, uses vertical wells and a method like reverse combustion to open up the internal pathways in the coal. The process has been used in several operating facilities and demonstration projects. The second, tested in European and American coal seams, creates dedicated inseam boreholes, using drilling and completion technology adapted from oil and gas production. It has a moveable injection point known as controlled retraction injection point (CRIP) and generally uses oxygen or enriched air for gasification. The schematic below illustrates the CRIP method.

5. SCENARIO OF SYNGAS PRODUCTION

According to National Energy Technology Laboratory (NETL), USA, current industry syngas output has increased by 26% since 2007—and by 50% since 2004. China has seven plants under construction (six to convert coal to chemicals and fertilizers, and one to convert coal to power) [16]. An additional 10 gasification plants are being planned for operation by 2016 in China (eight to convert coal to chemicals and fertilizers, and two to convert coal to power). Two integrated gasification combined cycle (IGCC) plants are under construction in the United States, and growth is expected to continue with 16 projects planned for U.S. operation between 2010 and 2016 (combined, the 18 plants make up 47% of U.S. capacity growth for power generation, 23% for gaseous fuels, 18% for liquid fuels, and 12% for chemical facilities). Thirteen additional plants are planned worldwide—11 will use coal, and two will use biomass/waste. The gasification database (April 2014) of National Energy Technology Laboratory, USA, shows the number of proposed worldwide gasification projects having commercial potential summaries that 35 IGCC(Integrated Gasification Combined Cycle), 12 SNG(Synthetic Natural Gas), 25 CTL(Coal-to-Liquids), 9 CTC(Coal to Chemicals), 8 BTL(Biomass to Liquids), 3 WTE(Waste-to-Energy), 1 WTEth(Waste-to-Ethanol), 1CBTL(Coal-Biomass-to-Liquids), 3 GTL(Gas-to-Liquids), 1 PTL(Petcoke-to-Liquids) and 1 BTG(Biomass to Gas) [17].

Table 3. Summary of The Gasification Industry Worldwide, [16]

Feedstock		Operating 2010	Under Const. 2010	Planned 2010 to 2016	Totals
Coal	Syngas Cap.*	36,315	10,857	28,376	75,548
	Gasifiers	201	17	58	276
	Plants	53	11	29	93
Petroleum	Syngas Cap.*	17,938			17,938
	Gasifiers	138			138
	Plants	56			56
Gas	Syngas Cap.*	15,281			15,281
	Gasifiers	59			59
	Plants	23			23
Petcoke	Syngas Cap.*	911		12,027	12,938
	Gasifiers	5		16	21
	Plants	3		6	9
Biomass / Waste	Syngas Cap.*	373		29	402
	Gasifiers	9		2	11
	Plants	9		2	11
Total Syngas Capacity		70,817	10,857	40,432	122,106
Total Gasifiers		412	17	76	505
Total Plants		144	11	37	192
* MWth					

6. PROPOSED COAL-GASIFICATION BASED SYNGAS ENERGY INFRASTRUCTURE

In this paper, we proposed an infrastructure, which based on Coal-Syngas. In this infrastructure coal is converted to syngas by a central gasification plant, which will situated at high density industrial area. Then, the produced syngas purified through purification plant situated beside of gasification plant. Then cleaned syngas processed to make Synthesis Natural Gas (SNG) in syngas transmission station. The syngas transmission station will maintain a fixed pressure in pipeline transmission, for this purpose there would be a large reserver to reserve syngas in the time of peak generation. Then it transmitted through a dedicated pipeline or injected into existing natural gas pipeline. The syngas distributed station will manage the distribution among the different types of user like Household, Thermal Power Plant, Brick Field, Ceramics & Glass Industry and any kind of thermal process industry. This proposed technology will reduce the dependency on natural gas and help to build a sustainable energy plan for future. Energy crisis is becoming the first national problem of Bangladesh. The proposed infrastructure could finance by government or the International Organization who donates for health or environmental issues, like World Health Organization (WHO).

Coal syngas can be transmitted through pipeline. According to Joule A. Bergerson et. all, summarizes the specific assumptions for different types coal energy transmission methods. The gross plant capacity is different for each option due to the plant characteristics and the additional power required compensating for losses. The IECM software used to model the pulverized coal plant assumed it meets new source performance standards and has efficiency (HHV) of 34%. The overall efficiency of coal by rail is overstated since it does not include the 10 milion gallons of diesel fuel required for transport [18].

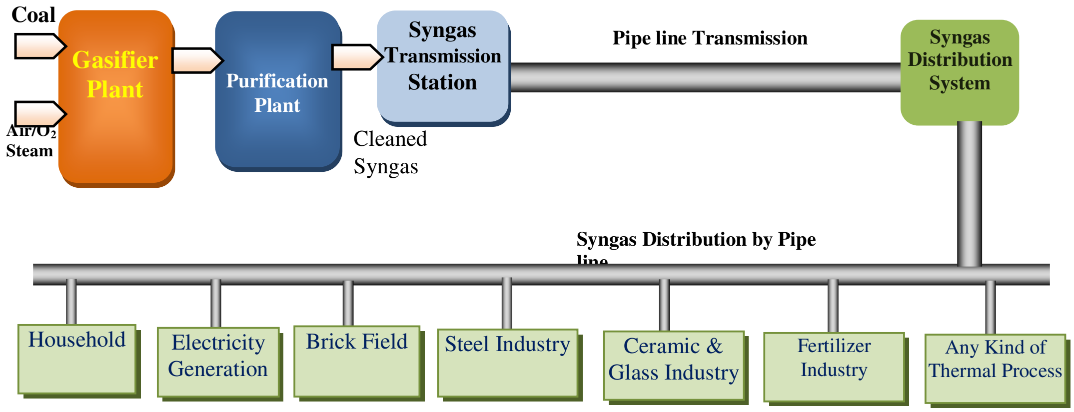

Fig -5: Proposed Coal Gasification Based Energy Infrastructure.

The gasification and methanation process is modeled after the Lurgi gasifier and methanation process currently in operation in North Dakota. This fixed-bed gasifier operates under conditions which make it better equipped to handle the high (and variable) ash and moisture content in the PRB coal. Due to the slightly higher reactivity of the PRB coal (compared to the lignite currently used in the North Dakota plant) a slightly lower efficiency was assumed 69%, [19]. The IECM software models the Natural Gas Combined Cycle (NGCC) unit and calculates efficiency (Higher Heating Value) of 49%.

Performance and costs of coal gasification plants depend largely on the plant design and on the final production objectives. A gasification system that is part of an integrated chemical plant producing methanol, ammonia and electricity differs substantially from a system whose only purpose is feeding an IGCC plant with carbon capture and storage (CCS). Coal quality is also very important for coal gasification output. The overnight capital cost of coal gasification plants is given per GJ of syngas output and ranges from \$13/GJ for bituminous coal to \$17.2/GJ for subbituminous coal (US\$ 2005).

Similarly, the syngas production cost decreases with increasing coal quality and ranges from \$15.6/GJ to \$19.3/GJ. The production cost is dominated by the investment cost. However, costs may significantly depend on location. Chinese plants may cost 60%-65% of the US and European installations. Syngas may be further upgraded to meet specific demands. Co-production of a 20% of H_2 using a H_2 separation unit is only slightly more costly than the basic process, resulting in 5% higher capital and 4% higher product costs. The conversion into synthetic natural gas (SNG), i.e. pipeline quality gas, requires additional processes and costs. If the syngas is converted into SNG, the capital cost increases by approximately 25% and the cost of the final product increases by 40%, while the conversion efficiency of the process decreases by some 14 percentage points, reaching about 60%.

As per requirement of the study on coal sourcing, transportation and handling, the international visits and open discussion with stakeholders playing important roles in coal business were necessary. In general, South Africa and Australia are sustainable source for coal having GCV of above 6000kcal/kg. On the other hand, coal having GCV 5000 to 5800 are easily available in Indonesia but there are some challenges that have to be overcome before sourcing coal from Indonesia. To ensure sustainability of the coal supply, GOB should source coal from multiple countries, multiple suppliers and engaging multiple shipping agents. In terms of cost, sourcing from Indonesia would be cheaper due to low transportation cost and low cost of coal (GCV 5000-5800). Besides, transportation cost would be higher in case of South Africa and Australia. However, actual cost of the coal completely depend on size of the vessel to be used, and loading and unloading facilities at loading and unloading port. On the other hand, Mozambique is a new entrant in the world coal trade. A huge investment in exploration, exploitation of coal, as well as development of infrastructure (roads, railway, ports, etc) is going on there in Mozambique. It is expected that, in next five to seven years time it would be one of the major coal exporting country in world. It would be prudent for Bangladesh to contract the relevant stakeholders of Mozambique coal business at this stage for sourcing coal.

Considering the competitive market, it would be convenient for BPDB to make necessary arrangement for coal sourcing (e.g. offtake agreement with producers) from these countries under the active support of the government.

According to CEGIS recommendation, the following suggestions may be made:

>> Coal should be procured from multiple sources (multiple suppliers and multiple countries) for ensuring continuous and sustainable supply.

>> Australia would be a sustainable source for coal of higher GCV value (above 6000 kcal/kg)

>> Indonesia would be suitable source for coal of 5000 to 5800 GCV subject to above mentioned challenges are successfully handled

>> Long term agreement with coal trader/suppliers would be suitable mode of coal sourcing (considering present knowledge of mine operation and investment)

>> Offtake agreement (FOB Mother Vessel basis) with coal producer may be the suitable mode of coal sourcing. However, investment in mine under JV agreement may be the future option after earning enough experience and knowledge in coal business including mine operation.

>> Long term agreement needs to be made with multiple coal transportation agents/shippers for continuous supply of coal.

>> BPDB will need to engage a survey and inspection agent for proper inspection and monitoring of coal supply system, coal quality and coal quantity.

>> Govt. should form a dedicated team comprising Ministry, BPDB, and other stakeholders at the earliest possible time with the responsibility of initiating coal sourcing and transportation.

>> Government should also assign responsible officers in the Embassy of Bangladesh at Jakarta, Indonesia and High Commission of Bangladesh at Canberra, Sydney and South Africa for coordinating the coal supply to Bangladesh.

There are enough coal resources in reachable distance to Bangladesh. Price per kcal, reliability of the source and the convenience of the transportation chain will be the criteria influencing the decision making process. BPDB should thoroughly define their advantages in this process. The long-term demand and the support of the Government are major assist in these negotiations. Generally, the mining companies prefer this long-term thinking as well, traders like the "quick money". The development of the domestic resources should become a part of this strategy. It well might be that the mining companies providing the import coal are of assistance to develop the domestic resources.

7. CONCLUSIONS

Growing emphasis on coal gasification technology is aimed at reducing the environmental impact of coal energy conversion. According to World Coal Association, the biggest market for coal is Asia, which currently accounts for over 67% of global coal consumption; although China is responsible for a significant proportion of this. Bangladesh does not have natural energy resources sufficient to cover their energy needs, and therefore need to import coal to meet the demand. The gas peak worldwide has alarmed its ring long back. The scenario is no different here in Bangladesh. The unquenchable thirst for the natural has come in existence. The connection of a natural gas in household for cooking utilities are far in reach which aware and help explain the severity of gas crisis era of the country. SNG production from coal or biomass is currently under strong investigation due to rising prices of natural gas and the wish for less dependency from natural gas imports. The interest is high especially in USA and China. So, the technical assessment of different technological alternatives for SNG production is an important research topic. This paper illustrates the whole scenario of synthesis gas production from coal and proposes an infrastructure for central production, transmission and distribution on Bangladesh perspective.

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