Proposal for the Appropriate Natural Gas Utilizations in Developing Countries – Sudan as Case Study

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***Abstract*- The paper considers Natural Gas utilizations worldwide and the developments in its sectors, and the global consumptions with some suggestions and recommendations on how to exploit Natural Gas reserves developing countries and in Sudan as a case study. It is predicted that Natural Gas would be an important fuel for power generation and main raw material for a plethora of industries in the decades to come. Projections for year 2040 are that Natural Gas would consist of about 29% of the total energy consumed in the world, with corresponding 33% to oil. It is also suggested that the use of cogeneration plants in Sudan would benefit in power and space cooling generation stations that use Natural Gas in the near future. Petrochemical industry is also an important and crucial sector in which Natural Gas constitutes most of the raw material, and therefore it is highly recommended to be introduced in Sudan for domestic use and export. LNG and its re-gasification are also reviewed; the re-gasification capacity has been growing gradually since 2006 from 0.8% and has currently reached 8.8%. The design for a Natural Gas driven train engine is included in this report, to encourage using Natural Gas trains and Metros in the future.**

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I. INTRODUCTION

Natural gas has become an important natural resource in the past recent years; this can be acclaimed to its many pros, ease of use and advancement in its transportation technology, low environmental footprint and low price. Globally, this resource finds an unprecedented acceptance from many governments and global companies. Some countries such as Russia and Qatar have amassed great influence, wealth and GDP growth by discovery of large Natural Gas deposit reserves, the produced natural gas is supplied to Europe to cater for their energy demands.

In the twenty first Century, Natural gas became a major energy source for industrialized nations in the world (Schramm), this was in reference to the low natural gas prices historically, to the trend of natural gas consumption sharply increasing, " in 1980, 20% percent of the global energy consumption by OECD countries was natural gas, while in non-OECD countries the percentage was just 5%, and generally in the short term consumption and future projection, Natural gas share in world primary energy supply is projected to increase from an estimated 21.3% in 2013 to 23.6% in 2035 to the detriment of other fossil fuels (CEDIGAZ, 2015)". In considering the fiscal perspective, future natural gas prices will be greatly influenced by a number of factors including resource availability, oil prices and demand for natural gas (John Conti, 2015).

Natural gas utilizations have increased also by introducing of new gas feature i.e. LNG, CNG and gas-to-liquids. OPEC countries are expected to produce more than 300 Mbbl/d of gas-to-liquid in 2020, meanwhile non-OPEC countries produce more than 100 Mbbl/d nowadays and this rate is expected to increase to 200 Mbbl/d by 2040. (John Conti, 2014).

Liquefied natural gas (LNG) will continue to hold an important role in the natural gas and energy industry. The advance in LNG technology is used for natural gas supply operations; imports via tanker ships and domestic storage, and in consumption such as for vehicle fuel LNG is natural gas that has been cooled to about minus 260 degrees Fahrenheit for shipment and/or storage as a liquid. LNG is more compact than the gaseous equivalent with a volumetric difference of approximately 610 to 1.The physical properties of LNG's enable overcoming of limitations encountered in natural gas transportation and storage. The advantages are that it allows for long-distance transport of LNG by ship across oceans to

markets such as the United States and local distribution by truck onshore. (Gaul, 2003).

I. NATURAL GAS UTILIZATIONS SECTORS

The main Gas Utilization sectors could be included in, Industrial, Petrochemical, Power Generation, City Gas, House Hold, Transportation, and LNG, LPG, CNG, GTL and other related gas product. Figure (1) shows natural Gas consumption trend in Africa in Bcf.

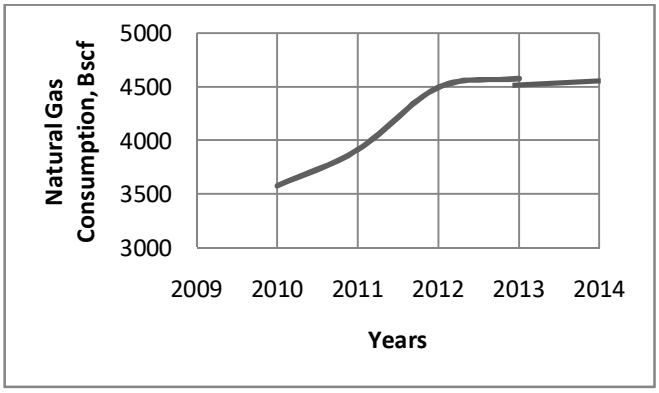


Fig. 1: Africa Natural Gas Consumption (After Iea)

In many developing countries natural gas in not exploited as well as possible and it is flared in many cases. The utilizations of natural gas there must be from where the developed countries are there now. Figure (2) shows the modern natural gas uses:

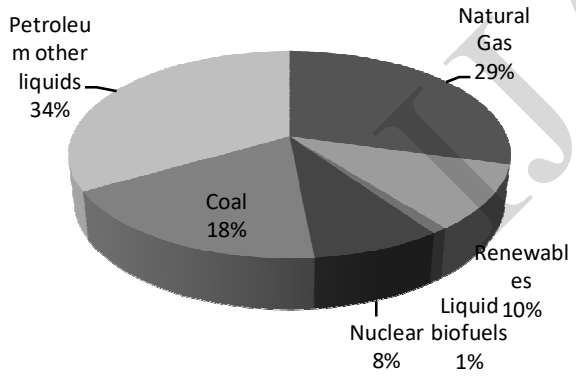


Fig. 2: 2040 Primary Energy Consumption Projections in the United States

Major Natural Gas Utilization Sectors:

- Industrial
- Petrochemical
- Power Generation
- City Gas, House Hold,
- Transportation
- LNG, LPG, CNG, GTL and other related gas product

II. NATURAL GAS CONSUMPTION WORLDWIDE

Gas is used in many sectors globally, this is due to its high efficiency and sustainability, in the United States, natural gas shares about 25% of the total industrial production including manufacturing, construction, agriculture, and mining (John Conti, 2015). Total dry natural gas production in the United States has increased by 35% from 2005 to 2013, with the natural gas share energy consumption rising from 23% to 28%. The Production growth has largely resulted from the development of shale gas resources in the Lower 48 states (including natural gas from tight oil formations), which more than offset declines in other Lower 48 onshore production (John Conti, 2015).

In Sudan natural gas is still rarely used for the sectors in which natural gas is used in United States, in spite of the fact that the proved natural gas reserve in Sudan is above 3 Tscf (EIA, 2015). In agriculture, many of projects in Sudan are operated by the electricity from dams, which are good and sustainable sources of energy, but in too far distances from dams, electricity needs many Electricity transmission towers to reach these regions, the thing which will increase the CAPEX of such a project. Instead of using dams' electricity, gas electricity power generation stations could be used to generate electricity in too far regions from the national electricity network.

Natural Gas is widely used for electricity generation in the United States, making up about 25% of the total electricity generated. Gas consumption is Seasonal with the demand peaks in the winters whereas lower during the summers. In Electricity generation it is observed that the abandonment of some coal-fired capacity hence decline in coal-fired electricity generation over the past few years, the relatively low cost of natural gas has been a the significant driver. During the first half of 2015, coal accounted for 34% of total generation compared with 40% during the same period last year, while natural gas accounted for 30%, up from 25% during the first half of 2014. For all of 2015, EIA expects the annual amount of coal generation will be 8.2% lower than in 2014, and the annual level of natural gas generation will rise by 14.5% (EIA, 2015).

III. DEVELOPMENT IN NATURAL GAS UTILIZATIONS

Cogeneration plants are modern technology that used to generate power and benefits from the consumption heat in other issues like homes heating for instance. Gas district cooling plant is one of Cogeneration technologies that is used widely.

III.1 GAS DISTRICT COOLING PLANT (GDC):

Combined or Cogeneration heat and power (CHP) is the use of a heat engine or power station to generate electricity

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and useful heat at the same time. Combined cooling heat and power (CCHP) or Tri-generation, refers to the simultaneous generation of electricity and useful heating and cooling from the combustion of a fuel or a solar heat collector.

Cogeneration is a thermodynamically efficient use of fuel. In separate production of electricity, some energy must be discarded as waste heat, but in cogeneration this thermal energy is put to use. All thermal power plants emit heat during electricity generation, which can be released into the natural environment through cooling towers, flue gas, or by other means. In contrast, CHP captures some or all of the by-product for heating, either very close to the plant, or—especially in Scandinavia and Eastern Europe—as hot water for district heating with temperatures ranging from approximately 80 to 130 °C. This is also called combined heat and power district heating (CHPDH). Small CHP plants are an example of decentralized energy. By-product heat at moderate temperatures (100–180 °C, 212–356 °F) can also be used in absorption refrigerators for cooling (Hunter, et al., 1991). The GDC plant is a cogeneration plant which produces both electric power and chilled water for space cooling. Malaysia has a unique experience in cogeneration cooling plants.

Cooling plant It consists of gas turbine engine, heat recovery steam generator, steam absorption chiller, air cooled chiller, cooling tower, and thermal energy storage. The gas turbine engine drives the electric generator for production of electrical power. The exhaust heat from the gas turbine is utilized for steam production which is needed for heating in the steam absorption chiller. The chilled water produced from the steam absorption chiller is used for air conditioning of the buildings in UTP towers “Malaysia”. The air cooled chiller also produces chilled water and is used for space cooling in UTP. The cooling tower is part of the plant because it is cooling the recycling water of the steam absorption chiller. TES in the plant acts as a storage tank for chilled water that is used during peak period. Cogeneration is a form of energy conservation process, because of the heat energy recovery that can be lost from the gas turbine exhaust (YONGO, 2010). The layout of the whole GDC is shown in the Figure (5) in the appendix.

Another interesting development that occurred in the industry of natural gas is LNG, and the reverse process is the regasification, the regasification capacity has been growing gradually since 2006 from 0.8 and it reached 8.8 % in 2015. In the main, the global LNG industry can look back on 2014 as another year of relative stagnation with LNG trade reaching 239.2 MMT, a 1% increase over 2013, but just below 2011 levels. Although one new liquefaction plant came on stream in May in Papua New Guinea and one expansion train started producing in Algeria, disappointments in Angola and Egypt and slowdown in Qatar limited the volume of additional LNG supply. Low demand in South Korea as well as slower than expected growth in China contributed to loosen the market tightness observed in recent years, foreboding the return of a buyers’ market as the year progressed. (GIIGNL, 2015)

III.2 NATURAL GAS USE IN PETROCHEMICAL INDUSTRY:

The basic components in natural gas are methane, CH4, while petrochemicals consist of many carbon atoms connected in various conformations. inGAP (Norwegian petrochemicals institute) has chosen a few areas in which they focus on the production of building blocks for petrochemicals. For instance ethene and functionalisedethenes are molecules required for making various plastic products.

As the name implies, petrochemicals are chemical products manufactured from petroleum. The large majority of chemical products are produced from petroleum (oil) or natural gas. Sometimes, coal or biomass is employed. Among the petrochemical products, we find plastics, such as polyvinylchloride (PVC), polyethylene, polypropylene; synthetic fibers such as polyesters, nylons; elastomers which are rubber-type materials; fertilizers; pharmaceuticals; paints; detergents; insecticides; vitamins; etc. Most of these products are made from surprisingly few chemical intermediates, referred to as base chemicals:

- Light alkenes - ethene, propene, and butadiene.
- Aromatic compounds - benzene, toluene, and xylenes.
- Synthesis gas (carbon monoxide and hydrogen and products made from syngas - ammonia and methanol.

Several of these base chemicals may be made more readily from natural gas rather than petroleum. Synthesis gas is an obvious candidate, due to the high hydrogen content of natural gas. Moreover, the light alkenes may be made from wet natural gas (NGL) in a process known as steam cracking. (inGAP, 2011).

IV. NATURAL GAS FUTURE POTENTIAL UTILIZATIONS:

It is expected that Natural Gas would consist about 29% of the total energy consumption by 2040, meanwhile oil will consist 33% of the total energy consumption (John Conti, 2015), this percentage is relatively high and it gives signals that gas importance would grow and it would be a highly needed power material. The primary energy consumption in 2040 in IEA projections, it could easily be observed that Natural Gas would take the second place after oil immediately.

V. NATURAL GAS ENVIRONMENTAL IMPACTS

It is known that Natural gas is the most effective fuel that emits carbon dioxide, major companies always turn to Natural gas to reduce CO2 emissions and to carry out the fuel switching from oil and coal in the industrial sector where fuel consumption is large.

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The advantages of natural gas could be summarized in (Natural Gas Facts & Figures, New Approach & Proposal, 2015):

- By using Natural gas it is Easy to reduce CO2 emission, generally, natural gas is the least CO2 emitting fuel among all fossil fuels including diesel and gasoline. Only shifting to natural gas, CO2 emission can be reduced by20% from heavy oil and 40% from coal.
- Easy to achieve massive energy saving
- Easy to improve customers product quality and yield of product
- Good affinity with renewable energy.

VI. NATURAL GAS USES IN SUDAN

In Sudan, Natural gas is not widely used, it is just used in cooking, bakeries, and we had an unsuccessful experience with the utilization of gas for public transport facilities. Total electricity generation in Sudan and South Sudan was 9.7 billion kilowatthours (kWh) in 2012 (SETCO, 2012). No watt of this electricity was generated by natural gas and the majority of electricity isHydroelectricity which shapes 68% of Sudan generation. Thermal power plants also have a significant share in electricity generation in Sudan.

An important potential problem related to hydroelectricity is the occurrence of accidents that could happen with electricity transition lines, in 2012 more than 360 accidents occurred in these lines in Sudan (SETCO, 2012), these incidents logically would be minimized in case of using natural gas instead because there will be less transition lines.

In Sudan, although power generation has more than tripled since 2000, there are millions of people still without access to electricity and with accordance to the International Energy Agency (IEA), only 29% of Sudan's population had access to electricity in 2011. The value of flared Natural gas in Sudan equals $6 million per day, which is a great amount that should be benefited from,

VII. DISCUSSION AND RECOMMENDATIONS

Natural gas can be used to operate trains, ferries, or the transport facilities that are not subjected to accidents usually. The small transport facilities like cars and buses are not advised to turn to gas, because in case of accidents it will be deadly. In Electricity Generation generally, it is recommended to be used, especially in regions near oil fields in which gas is flared. There are many types of electricity power generation stations which work by gas could be established in Sudan like, Natural Gas - Thermal power stations, Distillate - Open Cycle power stations Natural Gas – Open Cycle power stations, Natural Gas – Combined Cycle power stations,. One case scenario would be to include zero flaring units in the Sudan oil field processing facilities. The captured gas in zero flaring can be used to generate electricity using any of the above mentioned Natural Gas power generation systems. This would results in significant cost saving and reduce the environmental footprint.

In Sudan Petrochemical also can be made in case of producing natural gas by high quantities, Aromatics-based Petrochemical could be made to be used instead of the imported Aromatics. Butane-based Petrochemical like LPG.

Furthermore, Propane-based petrochemicals could be used in welding and other steel industries. In the other side, Ethane-based Petrochemical also could be made in Sudan. Primary Petrochemical could be divided into three groups depending on the chemical structure, Olefins, Aromatics and Synthetic gases, which are used to make ammonia and methanol. By wise planed strategies, a lot of Petrochemicals can be made here in Sudan, because Natural Gas is the raw material of most of them. Natural gas also can be encouraged by providing the following incentives:

- Import duty and sales tax exemption on conversion kits;
- Road tax reduction for Mono-gas vehicles, Bi-fuel vehicle, Dual-fuel vehicle
- Accelerated capital allowance for the purchase of mono-gas buses and construction of NGV outlets
- Heat treatment
- Setting NGV pump price at 50% lower than petrol (gasoline) pump price
- Industrial, Commercial and Residential Users
- Steam generation
- Co-generation
- Heating furnace
- Melting
- Food processing

Gas District Cooling (Space Cooling) is also recommended to install in Sudan, these unique turbines could save for us a lot of costs and it use the heating generated from electricity generation in purposes of cooling or heating.

VIII. CONCLUSION

Gas investments are attractive in Sudan because of the high initial CAPEX, however for the market trends and observations in gas producing countries like Qatar and Russia, they achieve lucrative and sustainable business. Thus natural gas investments are highly recommended in Sudan.

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