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Fuel Switching for Market Competency-Sustainability in Bangladesh

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Abstract: ***Bangladesh is to sustain the present index in gross national income, human assets and economic vulnerability to qualify to leave Least Developed Countries (LDC) bloc. To accomplish the tough task, in context of depleting affordable prime energy source (natural gas) with surge in demand, leading to import of costly fuel and loss of preferential export benefit (additional tax) on its export , Bangladesh is to facilitate its export oriented industries with affordable and clean energy source to sustain market competency. This paper deals with low cost technologies applicable to achieve affordable and reliable energy options for industrial sector in electricity & steam generation and gas production for Kiln/Furnace operation.***

Keywords: Low cost technology, affordable & sustainable energy, onsite CHP, cold coal gas & clean environment

1. Introduction

Indigenous natural gas has been the prime and primary energy source for gird electricity generation, fertilization production and industrial captive generation, steam production and process heating. The production of the prime fuel has been depleting with peaking in 2017. Out of 20.80 TCF proven recoverable reserve 12.10 TCF has already been consumed. Remaining reserve 8.70 TCF corresponds to (reserve to production ratio) 9.5 years only. The real GDP (2005 constant price) as of 2041 is estimated to reach 38 trillion BDT, about 4.60 times of current level (8.20 trillion BDT). The average GDP growth rate from 2016 to 2041 is estimated 6.10% p.a. The ratio of industrial sector's energy consumption to GDP is creeping up (GDP elasticity is higher than one). It indicates that the economic development is still at an early stage and that a shift from labor-intensive industries to energy consuming is still in progress. The energy consumption will be about 54,500 Ktoe, about 7 times increase in 2040 from 2015. The industrial sector's share is exceeding 20%. Sustained economic growth and urbanization is stimulating a rapid increase in country's energy consumption both in domestic and industrial sectors [1].

It is to be noted on March 16, 2018, United Nations committee for advancement policy (CPD) announces Bangladesh's eligibility of leaving LDC bloc in 2024 with a grace period of three years to consolidate its new economic standing. CPD will observe country's progress in 2021 – 24. The graduation from LDC bracket will lead to erosion of trade privileges and loss of concessional lending terms from development partners. After graduation, Bangladesh's exports will face an additional 6-7% tax. United Nations conference on Trade and Development estimated an export fall of 5.5 to 7.5% after graduation leading to loss of about $ 2.70 billion in export earnings every year (ERD, GOB). It is worth to mention here that in 2016 Bangladesh exports $24.70 billion to preference granting countries which accounts 72% of total exports. To counter, the losses Bangladesh has to upgrades technology, skill endowment, productivity enhancement and higher competitive strength [2, 3].

To replenish the gap in energy deficit and depleting natural gas reserve and continuous surge in energy requirements, GOB is planning to import primary fuel: Liquid, LNG and Coal. Due to constraints in infrastructures LNG and Coal import will be increased step by step. The inception will be with a humble amount of 500 mmcfd LNG per day. This LNG will be gasified and blended with indigenous gas and will be available for consumption within June 2018. Simultaneously development of infrastructures for coal import and utilization specifically in ultra-super critical power stations and in other energy demand is in progress.

Traditionally in Bangladesh the primary fuel (natural gas) was a subsidized one to boost local industrial product and capture export market. Bangladesh is the second garment exporting country thanks to affordable and reliable energy. With the inception of LNG import government has already re-fixed the energy price (LNG). The following table illustrates the present and proposed energy price which will be applicable from June 2018.

Bangladesh's per cubic meter gas price

Sectors	Current price	Price if draft of hike passed
Power sector	Tk3.16	Tk4.99
Fertilizer sector	Tk2.71	Tk4.75
Captive power	Tk9.62	Tk14.98
Industrial gas	Tk7.76	Tk14.90
Commercial gas	Tk17.04	Tk35
Household gas	Tk9.10	Tk11.20
CNG	Tk32	Tk51.70
Tea sector	Tk7.42	Tk12.10

- LNG will be introduced to the national gas grid from May 2018
- Imported LNG will be three times more expensive than locally extracted natural gas
- Petrobangla will import LNG from Qatar, Oman, Switzerland
- BERC allocated Tk7,000 crore to Energy and Mineral Resources Division from its Energy Security Fund for the purposes of LNG import and operations of LNG terminals
- Security Fund has received around Tk3,552.65 crore as of March 2017.
- Energy Security Fund was created on September 2015 by BERC through a hike in gas prices for research work on developing the energy sector

Figure 1: Gas price in Bangladesh measured in per cubic meter

The present at site market price of imported coal is BDT 11,000 per Metric ton. The figures in the table indicate a gloomy picture of energy cost that will prevail in the country. It is a surge of 67% and 100% for captive power generation and industrial utilization (Boiler and Furnace /Kiln) [4].

2. Contribution of Industrial Sector to Bangladesh Economy

The following Table 1 illustrates the Bangladesh's export earning in FY 2017, which stand at $34.83 billion. The sector wise distribution is as follows.

Table 1: Sector wise distribution of export earning in FY 2017 (in USD billion)

Sector	RMG	Jute	Leather	Fish	Agro
Rev.	28.14	1.05	1.38	0.53	0.57
Sector	Plastic	Pharm.	H-Tex	Eng.	Ceram.
Rev.	0.15	0.10	0.88	0.88	0.40

Total export earning was $ 34.83 billion with RMG contribution 80.7% and ceramic 1.15% respectively. RMG is the major sector and ceramic is emerging sector [5].

2.1 Contribution of Readymade Garment (RMG)

Bangladesh has emerged as a key player in RMG sector since 1978.Textile & clothing account for about 85% of total export earnings. The sector employs more than 1.5 million workers from under privileged social classes. The pivotal factors in apparel industry have been affordable energy (indigenous gas) and local workforce. According to IMF, Bangladesh economy is the second fastest growing major economy with contribution of industrial sector to Bangladesh GDP was 28.0%. Average GDP growth in Bangladesh is 6.5%, which has been driven by its exports, prominently by readymade garments. The following table 2 illustrates the year wise RMG sector export values since 2007.

Table 2: RMG Sector's export value (Billion USD) [7]

Year	2007	2008	2009	2010	2011	2012
Value	9.35	11.88	11.89	14.85	19.21	19.79
Year	2013	2014	2015	2016	2017	2018
Value	23.50	24.58	26.60	28.67	28.14	37.50

2.2 Contribution of Ceramic Industries (Ceramic Expo Bangladesh 2017) [8]

Description of Ceramic industries in Bangladeshis shown in figure 2.

3. Status of Natural gas supply to industries in Bangladesh

The average daily gas output is 2700 mmcfd with a demand of 3500 mmcfd. This shortfall in supply has been prevailing and widening since last few years, with a shortage of about 1000 mmcfd now a day. Due to the potential shortfall in supply, the qualified gas supply (adequate volume, specified and stable pressure) is absent. These constraints in gas supply compelled the incumbent industries to sustain production losses (in volume and quality) and failures to achieve time bound production and shipments. Consequently these tremendous revenue losses are threats potential to their sustainability. To cope with the demand GOB is hopeful to commission 500 mmcfd LNG supply in April and another 500 mmcfd in October, 2018.

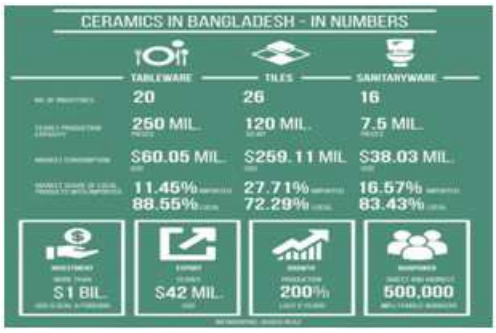

Figure 2: Ceramics in Bangladesh

To assess the grave concerns of perennial shortage of gas supply and its impact on production & revenue losses, survey and study have been carried out in a ceramic industry and in a composite textile mill. The industries are located within the 40 km and 80 km radius from city center. The ceramic industry utilizes gas for captive generation and process heating/burning. The composite textile mill utilizes gas for captive generation, steam production and in dyeing & finishing machineries. Both industries are of continuous production industry. The disruption in gas supply leads not only to production losses but also to losses in quality, leading to heavy losses of revenue. The survey and study period is May (2017) to Feb. (2018). The following tables illustrates the disruption durations of production/quality and revenue losses.

3.1 Composite Textile Mills

The factory's natural gas demands are 1500M³/h (captive generation), 1500M³/h (boilers) and 760M³/h (dyeing & finishing section). The required pressure is 15 psi for boilers and dyeing & finishing sections and 5 psi for captive generation. Due to shortage in supply volume captive generation, boilers and dyeing & finishing sections cannot be operated simultaneously.

Basically they operate boiler with grid gas as available and source electricity from grid which is 2 times costly than that of captive generation. They operate dyeing, & finishing sections with LPG (Liquefied petroleum gas) which is 5 times costly in limited capacities only.

Table 3: Monthly Gas availability in Composite Textile Mill (hrs), 2017-18

Section	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.
Avail.(hrs)	537	517	682	651	517	717	686	644	596	432
Steam Prod. (ton)	3463	2563	3769	4068	2909	4491	5009	4698	4486	2375
Cap-Gen (Mwh)	1341	988	556	207	697	230	848	1227	741	809
Grid Source (Mwh)	1315	1404	2130	2381	1686	2597	1958	1523	1837	1554

Limitations in dyeing & finishing sections compelled to under capacities utilization in spinning and webbing sections. Ultimately the factory sustains capacity non-utilization and revenue loss tremendously. Table 3 illustrates the survey findings.

It is evident from Table 3 in moths May (2017) to February (2018) grid gas in limited volume and lesser pressure was available for about 80% time, compelling the factory to operate in limited capacities. During this period, steam boilers were operated with an average production 5.0T to 8.0T per hour far below the rated capacities. Gloomier is the picture in captive electricity generation. At limited factory capacities utilization, the captive generation was 7644 Mwh (31.5%) and grid consumption was 16,559 Mwh (68.5%). The Dyeing-finishing section was operated with costly LPG in very limited capacities. The gas availability trend indicates the aggravated picture in future.

3.2 Ceramic Industry

The factory consumptions are 2200 M³/h (Kiln & Furnace) and 1050 M³/h (captive generation). The required pressure is 15 psi for Kiln & Furnace and 5 psi for captive generation. Due to shortage in gas supply volume Kiln-Furnace and captive generation cannot be operated simultaneously. When potential gas supply is available only then Kiln-Furnace and captive generation are operated simultaneously on gas. Since last few months due to severe shortage in supply & disruptions, the factory managed to operate on CNG, sourced from CNG stations, at a price 4 times of grid supply. In such a situation limited operation (Kiln & Furnace) has been carried out, which leads to severe production and revenue losses.

It is evident from survey grid gas in limited volume & lesser pressure with frequent disruptions was available for about 70% time compelling the factory to operate in under capacities. During this period, Kilns & Furnaces were operated with an average production (porcelain 50% time) and (bone china 60%) to far below the rated capacities. Reasonable is the picture in captive electricity generation. At limited factory capacities utilization, the captive generation was 2.50MW (70%) with no grid consumptions. The gas availability trend indicates the gloomier picture in future. In this context factory is planning to switch over to LPG operation with at site installation of LPG storage and gasification plants which is at least four (4) times costlier than grid gas operation. This will impact negatively on market competency and sustainability of the factory [6].

4. Importance of sustainable and clean energy options for market competency

The pivotal sector of export earning is RMG. The success of RMG has been facilitated by low cost energy (indigenous natural gas) and inexpensive manpower. As mentioned above due to depletion in gas production, GOB is importing LNG to replenish the ever widening shortfall. The indicative price of gas blended with imported LNG will be 2 to 3 times higher than the prevailing one (in figure 1). In context of facing 6.7% additional tariff (export to preference granting countries), and 2 to 3 times surge for primary fuel price and continuous enhanced labor cost – the industrial sector will face severe challenges to sustain its market competency. In circumstance coal in its cleanest form of utilization may pave the way to sustain export market competency.

5. Utilization of coal in its cleanest form

Coal is a dirty fuel. Nevertheless still it is most affordable fuel and will remain so. Worldwide 23% of primary energy needs are met by coal and 39% of electricity generated from coal. About 70% of world steel production depends on coal feed stock. Coal is the world's most abundant and widely distributed fossil fuel source[7]. Global coal demand is expected to raise by an average rate 0.5% p.a. meaning that coal use will stagnates for the decade to come (IEA). Thus ensures an stable price and sustained availability[8].

The major industrial sector in Bangladesh is Textile & Garment Sector. Ceramic is an energy consuming industry. Bangladesh industries are located in a scattered manner throughout the country. The primary fuel requirements of individual industries are for captive electricity generation (up to 20MW), on site steam production (up to 50 ton/hour) and process heating gas (up to 2000M³/h).

The primary fuel has so far been indigenous natural gas. The perennial shortage in supply compelled them to switch over to CNG, LNG and Liquid fuel with 3 to 4 times energy cost, just to continue limited emergency production for sustainability, leading to loss of market competency. Bangladesh is familiar with decentralized power generation philosophy and is operating such schemes since years back. Majority of the industries installed Captive power plants, Boilers and have process Kiln/Furnace operated on gas. There is competent manpower available in the country.

To overcome grave consequence of 2/3 times energy price hike and to have an affordable & reliable energy source, to sustain market competency and time bound supply, they have to switch over to coal utilization in its cleanest form. To ensure affordable cost and clean environment and highest efficiency CHP (combined heat and power generation) scheme and clean coal technology is to the deployed.

6. Clean Coal Technology for CHP (Combined Heat and Power) Scheme & Cold Coal Gas for Kiln - Furnace Operation

The prudent technologies for clean coal utilization are the use of coal in solid state (Pulverized coal), liquid state (CWS - coal water slurry) and gaseous state (producer gas). Any regular (dust/pulverized) coal-burning thermal technology is cumbersome, archaic and environmentally unfriendly featuring the following five principal aspects: Coal warehousing, coal feeding, coal crushing, coal dust feeding and filtering of smoke gasses. CWS is a unique patented process. The process ensures: Full combustion of coal, minimum productions of harmful substances and gases including co2, long duration storage (24 months). The cost of existing plant's fuel switching is not more than 13-15% of total cost of power plant.

Producer gas is a mixture of hydrogen, carbon monoxide, methane, carbon dioxide, water vapor and suspended nitrogen and suspended particle matter is a primary gaseous fuel. Benefits of producer gas includes: utilization of any grade coal, less water consumption, higher safety, higher utilization efficiency and least pollution. In coal gasification and coal gas boiler through a simple filtration and desulfurization the level of particulate materials and so2 can be reduced to 20mg/m³ and 50mg/m³ respectively. These values are far below international acceptable level. The cost of a 2 ton coal gasifier, 20t boiler with filtration and desulfurization units is less than US$ 1.0 million [8-16].

7. Fuel Switching to Coal / CWS / Producer Gas for Market Competency

Traditionally Bangladesh industries developed based on Natural gas captive electricity generation and steam production and Kiln & Furnace operation. Presently due to severe shortage in gas supply and enhancement of imported gas price in multifold, industries are facing potential production and revenue losses and have been depriving profit margin. **To counter lone option is affordable coal**. As mentioned above coal can be utilized as primary fuel in **solid, liquid and gaseous** states. Bangladesh Industries has operated on natural gas; as such the easiest way to **Fuel Switching** is the coal gas. Affordable coal gas can be produced and purified at site and can be utilized in simultaneous electricity generation and steam production and Kiln & Furnace operation. Thus uninterrupted and time bound production and shipments can be assured at a marginal cost enhancement for energy leading to potential profit margin. The inexpensive technology involved and process diagram is presented below [8-16].

7.1 Producer Gas Production and Utilization Process Flow Diagram (Non-Tar Coal Gasifier, Purification and Storage) - Cold Coal Gas Station

Following flow –chart is shown in figure 3 shows the detail procedures of how Producer Gas is extracted

7.2 Brief Process Description

Qualified raw coal is raised by grade ability conveyor belt to the top of the coal bin and sent into the furnace by coal feeding equipment. The coal under goes into the destructive distillation process in the gasification zone and the coal turn into the semi-coke and go into the lower part of gasification. The carbonized coal gas from the gasifier (temperature is 80～ 120℃, calorific value 7100～ 7500kJ/Nm3) goes through the oxidation layer(900-1200℃) in furnace and then the coal tar oil converts into CxHy and light oil through high-temperature pyrolysis. The outgoing coal gas temperature from furnace is 500℃, calorific value is about

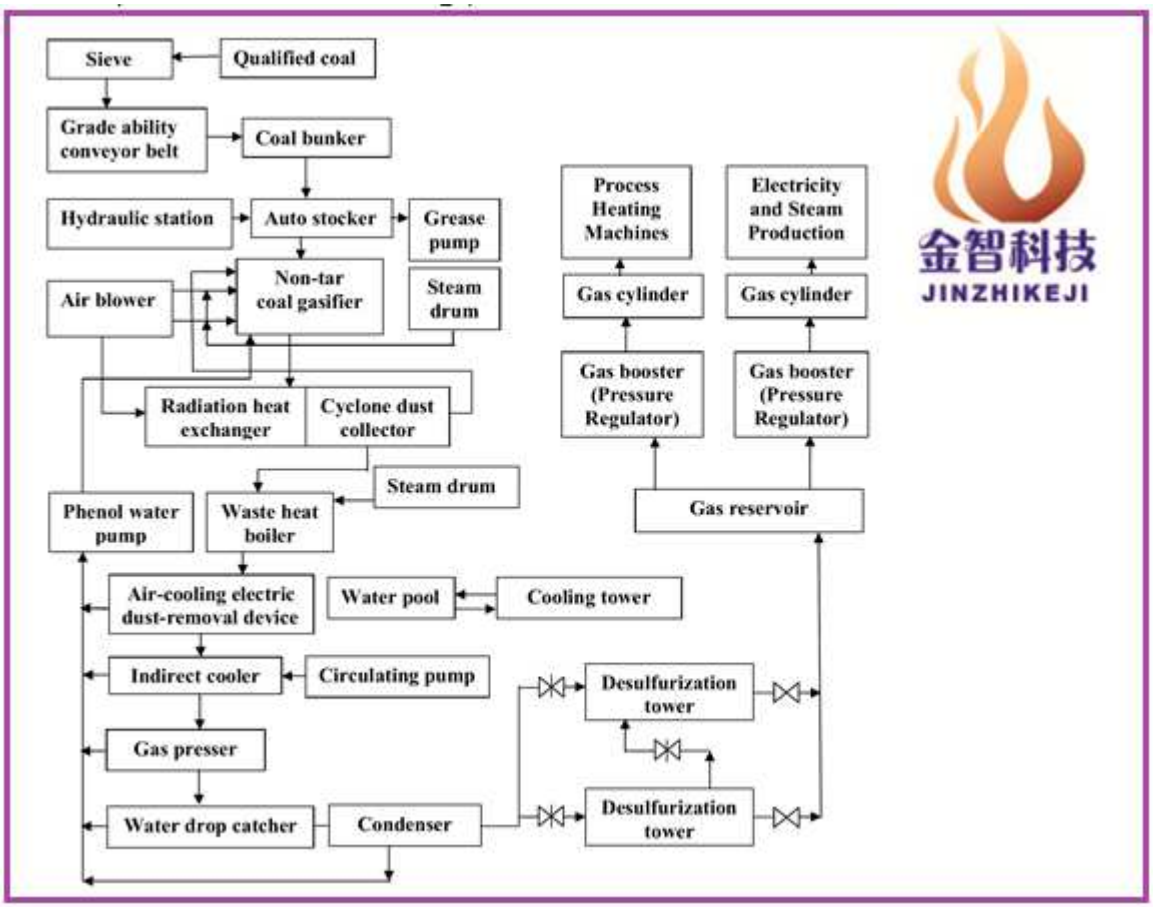

Figure 3: Producer Gas Production and Utilization process.

5016～ 5643kJ/Nm3. Then the coal gas goes into cyclone dust collector to remove most of dust within it and phenol water is evaporated through cyclone jacket. Then gas goes into heat exchanger and temperature is reduced between 120~200℃; and then it goes into indirect cooler to cool down and electric light oil catcher to remove light oil. At this stage, the content of tar oil is less than 30mg/Nm3.

The cold clean coal gas then flows into gas booster to boost and passes through desulfurization system; finally the gas flows into gas main to be transferred to utilization. The whole technology process adopts indirect cooling system to make sure the total content of tar and dust is less than 50mg/Nm3 .Purified, the cold coal gas will be sent to gas storage tank. From the storage tank, it will be boosted and sent through gas pipeline to the gas utilization tank in the utilization sections. It will then be sent to burners of the process kiln /furnace, Boilers & Gas generators by respective branch pipeline.

7.3 Traits:

a. Adopting non-tar coal gasifier to produce coal gas, gasification efficiency and thermal efficiency are high, high in automatic level, low in labor intensity and good operating environment; the coal gas produced in two stage gasifier has low impurity content, high and stable calorific value.
b. The process adopts phenol water pump to put the dirty matter with phenol water and a little tar oil into the furnace to be burned. This technology is to make sure the gas station to achieve target of environment protecting and safety dumping.
c. Dry desulphurization technology adopts active carbon (or ferrous oxides particle) as the desulfurization agent. The installation of two desulfurization tower can be both series operation (regular production) and parallel operation (replace filler) in order to make sure the efficiency of desulfurization is above 90%.

7.4 Characteristics of non-tar cold coal gas

a. There are abundant of CxHy、H2、CH4 in the coal gas produced from non-tar gasifier, and the calorific value is high.
b. The content of tar oil is much less. As the carbonized coal gas with coal tar oil flows high temperature oxidation layer, the tar oil is breakdown into the gas and light oil, reducing the tar oil output. This technology solves the problem of disposing taroil in area which is not advanced in chemical industry. The light oil can be saved easily and it can also be burned.
c. The gasifier is easily operated with full seam operating, automatic coal filling, automatic ash discharge and button start, which can reduce labor intensity greatly.
d. The whole process adopts dry purification without wastewater produced, reducing the Phenol water pollution, which is safer and environmental friendly.

8. Cost Comparison of Various Options

In a non-tar coal Gasification scheme with no phenol water discharge, a simple filtration and desulfurization can reduce the particulate material and So2 to 20mg/m³ and 50mg/ m³ far below international acceptable level is the cleanest form of industrial coal utilization. Investigation in the primary fuel cost of a composite textile mill that has been operating since a few years back. From inception the plant has been running on natural gas from the grid with captive generation capacity 4.0 MW, boiler capacity 30.0t/h and process heating gas load 650m³/h. In prevailing gas severe shortage different industries opt various options to secure primary fuel. The following are the prominent ones.

8.1 Present Option (grid natural gas operation)

The proposed gas price (imported LNG blended with indigenous gas) is Tk. 15.0/ m³ both for captive generation and industrial use. The primary fuel cost for 4.0 MWh electricity generation, 30.0t steam production and heating load of 650 m³/h gas, stands at BDT 61,500 per hour.

8.2 Option 1: Limited Gas supply option

Factory is to source electricity from national grid. Boilers & process heating plant operate on grid gas supply. The present grid electricity cost is BDT 10.0/Kwh The total cost both for electricity & gas stand at BDT 83,500 per hour.

8.3 Option 2: No gas - no electricity supply from grid

Factory is to source primary fuel for captive electricity generation, steam production and process heating devices. Basically, they source CNG from nearby station. The present market price of CNG at factory site is BDT 60/ m³. The fuel cost stands at BDT 246,000 per hour.

8.4 Proposed Option

The factory will run on coal. The coal will be gasified and filtered to produce clean coal gas to be utilized for electricity generation and steam production simultaneously in a CHP generation scheme and cold coal gas will be utilized in the process heating devices. Maximum coal requirement is 7.0 tons per hour for 4000 Kwh electricity generation, 30.0T steam production and heating load 650 m³/h (gas). The primary fuel cost stands at BDT 77,000 per hour.

It is to be noted for fuel switching to producer new plant and machinery for coal gasification and purification station (7.0 ton), CHP plant (30.0t/h steam and 4.0 MW electricity) and conversion of process heating devices (burners etc.) will cost about US$ 5.0 million. Now with a plant life of 10 years and per year depreciation 10% with an yearly operating hour 7000 hrs, the per hour depreciated value stand at US$ 71.42, @ conversion it stands at BDT 5,714. The total cost of coal with depreciated plant value stands at BDT 82,714 per hour.

The economic status of the options is enumerated below in Table 8.

Table 8: Primary Fuel costs in difference options

Options	Modalities	Hourly Primary Fuel Cost
Present option	Captive generation, Steam Production & Process Heating based on grid gas supply	BDT 61,500 per hour
Option 1	Limited gas supply: Electricity from grid and steam and process heating by gas	BDT 83,600 per hour
Option 2	No gas supply and No electricity supply operation by sourced CNG	BDT 246,000 per hour
Proposed option	Coal based operation-through Gasification and CHP operation for steam & electricity with cold coal gas for process heating	BDT 82,714 per hour (including new plant and machinery depreciated cost)

It is evident from the Table (8.1) the present option, utilization of grid gas for factory operation yields the lowest cost. But with limited availability, this option leads to production and revenue losses severely (Table 2.1(a)). Option 1 electricity from gird and boiler and process heating by grid gas expense stands at BDT 83,600 per month. In this case dual uncertainty prevail-disruptions in gas & electricity supply leading to production and revenue losses. Option 2: operation based on sourced CNG will costs Tk. 246,000 per month- multifold cost in comparison with first two options. Supremacy of Proposed option: Factory will run on coal through gasification.

The coal operation costs BDT 82,714 per month including depreciated cost of Plant & Machinery which is marginally costly than present option. However, it is a reliable and independent energy source, which facilitates plant to be operated uninterrupted sustaining production capacities and revenue earnings.

9. Conclusion

In present context Bangladesh is to pass two cross roads. First-achieving qualification to be graduated to a developing country and exit LDC bloc-it has to sustain all qualifying index amid loss of preferential export benefits with an additional tax of 6-7% on its export. Second- with severe depletion of indigenous natural gas-the lone affordable source of primary fuel, country is importing liquid fuel & LNG with a multiple surge in price. Although limited fuel will be available the constraints in gas supply and disruptions will be in place and be aggravated further. In situation, to overcome the concern of energy crisis and potential economic losses in industrial sector (major exporting sector), we have explored all prudent options for energy independency and security as applicable in Bangladesh (low cost, simple technology & environmental friendly). It has been observed that coal in its cleanest form of utilization (gasification, purification and CHP mode of operation) can facilitate industries with primary fuel independency & affordability leading to sustain production & market competency and to boost countries economic and social progress and facilitated its successful transition to a developing country in near future.

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