A COMPARATIVE ANALYSIS OF CENTRALIZED VERSUS DISTRIBUTED APPROACHES IN ELECTRICAL POWER GENERATION: A STUDY ON Furnace oil based Power plants of Bangladesh.

Submitted in partial fulfillment of the requirements for the Degree of Masters in Procurement and Supply Management

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DECLARATION

It is hereby declared that I am the sole author of this dissertation. It is also declared that this dissertation or any part of it has not been submitted elsewhere for the award of any degree.

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CERTIFICATION

This is my pleasure to certify that the dissertation entitled "**A COMPARATIVE ANALYSIS OF CENTRALIZED VERSUS DISTRIBUTED APPROACHES IN ELECTRICAL POWER GENERATION: A STUDY ON Furnace oil based Power plants of Bangladesh**" is the original work of Fukrul Islam Mazumder that is completed under my guidance and supervision. So far I know, the dissertation is an individual achievement of the candidate's own efforts and it is not a conjoint work. I also certify that I have found the dissertation satisfactory for submission to BRAC Institute of Governance and Development (BIGD), BRAC University which is a partial fulfillment of the requirements for the degree of Masters in Procurement and Supply Management.

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ABSTRACT

Organizations with centralized power generation have a single facility to generation and transmission their generated electricity with multiple grid substations in their supply chain. A single power plant can dramatically reduce per unit production costs by using the same equipment to produce electricity, allowing the company to achieve economies of scale. Research from the nonprofit organization PENDEKER Energy shows that centralized power generation organizations have generation costs that are about 3 percent lower than decentralized organizations. For an organization with $5 billion in annual revenue, this is a difference of $150 million. PENDEKER energy research also shows that raw material inventory turn rates and generation schedule efficiency are higher in organizations with centralized power generation. Centralized power generation can also enable better forecasting, more local jobs, consistent production and more effective use of limited resources. The cost of materials may also be lower for centralized generation sites that are located near the source of those materials.

Organizations with decentralized power generation enjoy many benefits that often elude companies with centralized plants. These advantages include flexibility, being closer to their customers, better and timelier information, more motivated managers and employees, and the ability to take advantage of low labor costs in different areas. When a company is physically close to its customers, it can be more flexible in meeting increasingly diverse demands. Greater flexibility means greater customization. Decentralized power generation not only improves the efficiency of decision-making but also empowers employees, letting them improve problem areas immediately without approval from a centralized organization. According to a study by Harvard University, decentralized production actually increases motivation and creativity by giving lower tier managers more responsibilities. When a manager is given a sense of ownership over an operation, efficiency increases among employees in both production and support positions.

Decentralized power generation has disadvantages as well. Multiple sites require a larger investment of capital to set up, the per-unit costs are higher than mass-produced generation made in a central plant, and maintaining organization-wide consistency in products and processes is a challenge.

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LIST OF ABBREVIATIONS AND ACRONYMS

APSCL – Ashugonj Power Station Company Ltd.

BERC – Bangladesh Energy Regulatory Commission .

BPDB - Bangladesh power development board.

COD- Commercial operation date.

CAPEX- Capital expenditure.

EGCB – Electricity Generation Company Ltd

EPC- Engineering procurement & construction.

FY – Fiscal Year .

FSA- Fuel supply agreement.

GWh- Giga watt hour.

GDP – Gross Domestic Product.

GOB- Government of Bangladesh

HFO – Heavy Fuel Oil.

HSD – High Speed Diesel.

HVDC – High Voltage Direct Current.

IPP- Independent Power producer.

MW- Megawatt.

MPEMR -Ministry of Power, Energy & Mineral Resources.

MDO- Marine Diesel Oil.

MGO – Marine Gas oil.

NWPGCL – North – west Power generation Company Ltd.

OPEX- Operational expenditure

PSMP- Power system master plan.

PPA- Power purchase agreement.

PGCB – Power Grid Company Of Bangladesh Ltd.

SIPP- Small Independent Power Producer.

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Chapter 1

Introduction

Bangladesh is a developing country with huge population. Development of a country mostly depends on ensuring reliable and quality power to everywhere in the country. Bangladesh power development board (BPDB) is responsible for all of the power generation over the country. The Board is under the Power Division of the Ministry of power, Energy and Mineral Resources, Government of Bangladesh.

Electricity is a key ingredient for the socio-economic development of the country. The government has given top priority to development of the sector considering its importance in the overall development of the country. The government has set the goal of providing electricity to all citizens by 2021. Adequate and reliable supply of electricity is an important pre-requisite for attracting both domestic and foreign investment.

As the power sector is a capital-intensive industry, huge investments are required in order to generate addition to the capacity. Competing demands on the government resources and declining levels of external assistance from multilateral and bilateral donor agencies constrained the potential for public investment in the power sector. Recognizing these trends, the government of Bangladesh amended its industrial policies to enable private investment in the power sector.

As on January-2017, total installed capacity of BPDB including Captive Power is **(13,179+2,200) = 15,379 MW**, **13,179** MW (Public Sector 7,054 MW, IPP, SIPP & Rental 5,525 MW & Power Import 600 MW) of Power Plants located at different parts of the country. The main fuel used for power generation is indigenous gas. In Fy-2014-2015, Total 22,163 GWh gross energy was generated in the public sector power plant under BPDB. In addition, total 19,255 GWh of energy was purchased by BPDB from Independent Power Producers (IPP, SIPP & Rental) and 3,380 GWh from Power import in the private sector. The maximum demand served during peak hours is 9,471 MW in May 27, 2017.

HFO based power generation come from either distributed or centralized generation. Distributed power plants install at distributed locations near load centers. Centralized power plants are typically located at the point of best resource availability. Currently there is a debate regarding which form of power plants should be used to meet Governments of Bangladesh vision 2021 requirements. Distributed and centralized power generation each have their own strengths and weaknesses. In this section we discuss the merits and demerits of each, while keeping in mind that the topic is not yet settled and is open for debate.

Distributed plants have the promise of supplying power during peak demand time (around noon) and close to the demand itself, thereby eliminating transmission loss. However, the intermittency of the plant output cannot be directly managed, and it is unclear how much distributed power plants the electrical grid will be able to support.

On the other hand, centralized power generation follows the current electrical power management model and may be located at regions where the resource is most available. But these stations require huge capital investments and may require new transmission lines to transfer power from the station to the consumers.

Chapter 2

Present and future of electricity sub-sector:

Expansion of industries, agriculture work, manpower, modern life style, health care and huge development in communication in Bangladesh resulted ever increasing demand of power. In 2015-2016 financial year contribution of power in GDP on static price was 1.45 percent. The power availability is still scarce against aggregate demand. Government of Bangladesh has undertaken various time bound plans to cater the demand of power. As power is the vehicle to transform the country as a middle income one, an unimaginable achievement has been attained during last seven years. The power generation capacity increased from 4,942 MW in 2009 to 15,379 MW in 2017. The per capita generation of power increased from 220 kwh to 380 kwh. Power user population has increased from 47 percent to 77 percent. According to master plan of government, power generation will be increased to 24,000 MW in 2021 and 40,000 MW in 2030.

Generation:

Most of the power stations in Bangladesh are based on natural gas, which is around 64% of the total capacity on the fiscal year (FY) 2017. On the other hand, gas is short supply and about 1500 MW of generation shortfall occurs in a day due to shortage of gas. Therefore, it will be very tough to provide more electricity generated from the natural gas in future. The daily reports of Power Grid Company Bangladesh (PGCB) show the decreasing supply of natural gas and more and more penetration of HFO-based power generation. Government of Bangladesh is trying some alternative to natural gas such as coal, renewable energy &Furnace oil based power plants under the fuel diversification program. So far, as the fuel is concerned, the generation capacity is 8,727 MW by Natural Gas, 2690 MW by heavy fuel oil (HFO), 1158 MW by high speed diesel (HSD), 280 MW by Hydro and 250 MW by Coal. Besides these, 500MW has been imported from India since November, 2013 via high voltage direct current (HVDC) transmission line and another 100MW imported by comilla –tripura 132 KV transmission line.

Table 2.1 shows the installed capacity of Power Plants in Bangladesh according to fuel.

Installed capacities of power plants in Bangladesh according to fuel.

Unit Type	Capacity(Unit)	Total (%)
Coal	250.00 MW	1.82 %
Gas	8727.00 MW	63.68 %
HFO	2690.00 MW	19.63 %
HSD	1158.00 MW	8.45 %
Hydro	280.00 MW	2.04 %
Imported	600.00 MW	4.38 %
Total	13705.00 MW	100 %

Bulk of the power in Bangladesh is generated by BPDB. There are other independent power sources as well. Power Division, Ministry of Power, Energy & Mineral Resources (MPEMR), and Bangladesh Energy Regulatory Commission (BERC) are the governing bodies of Power Sector of Bangladesh.

The following authorities are responsible for generating electricity in Bangladesh.

(i) Bangladesh Power Development Board (BPDB)
(ii) Ashuganj Power Station Company Ltd. (APSCL)
(iii) Electricity Generation Company of Bangladesh (EGCB)
(iv) North West Power Generation Company Ltd. (NWPGCL)
(v) Independent Power Producers (IPPs)

Table 2.2 shows the de-rated generation capacity and their market share for the five authorities of electricity generation.

Table 2.2: Various authorities, de-rated capacity and their market share.

SL No	Name of the Authorities	Capacity (MW)	Market Share
01	Bangladesh Power Development Board (BPDB)	5347	39.01%
02	Ashuganj Power Station Company Ltd. (APSCL)	1508	11.04%
03	Electricity Generation Company of Bangladesh (EGCB)	622	4.53%
04	North West Power Generation Company Ltd. (NWPGCL)	508	3.70%
05	Independent Power Producers (IPPs)	5120	37.35%
06	Imported from India.	600	4.37%
Total		13705.00	100%

All the generated power are purchased by the BPDB and then transmitted by PGCB to the customers premises.

Till July, 2017 the total generation capacity of Bangladesh is 13,705 MW the de-rated capacity is 12,921 MW. It should be noted here that 2.28 % and 11.95% of generated energy are lost due to transmission and distribution, respectively.

The major part of the generation comes from the natural gas, for which the cost of generation of per unit energy is lower. However, it is higher for HSD and HFO due to high price. Bangladesh energy regulatory commission reports state that 77.91GWh of energy is produced from 34.79 Million liters of Diesel costing diesel of about 30.364 Bangladeshi taka (BDT) per kWh of energy whereas it is 13.46BDT for Furnace oil, 3.7BDT for coal and 0.902BDT for gas-based generation on an average (only for BPDB Generation). However, these costs are only for fuel. The actual cost is much higher when other running and maintenance costs are included. It should be noted here that the overall thermal efficiency of the power plants is 33% and the annual plant factor is 45.02%.

Based upon the preliminary study of the Power System Master Plan (PSMP) -2010, the anticipated peak demand would be about 10,283 MW in FY2015, 17,304 MW in FY2020 and 25,199 MW in 2025. The policy envisions 800MW of power from renewable energy by 2015 and 200MW of power by 2020. According to PSMP- 2010 Study year-wise peak demand forecast is shown in Table 2.3.

Table 2.3: Year wise peak demand forecast.

Fiscal Year	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Peak Demand (MW)	6,765	7,518	8,349	9,268	10,283	11,405	12,644	14,014	15,527	17,304	18,838	20,443	21,993	23,581	25,199	26,838	28,487	30,134	31,873	33,708

Chapter – 3

HFO based power plant:

HFO, also known as "residual fuel oil", is based on the high viscosity, tar-like mass, which remains after the distillation and subsequent cracking of crude oil in order to produce lighter hydrocarbon products, such as petrol , distillate diesel fuels and heating oil or feed stocks for lubricants.

The main components are alkanes, cycloalkanes and different carbon hydrides. The boiling range is between 300°C and ~700°C.Due to its semi-fluid consistence, HFO has to be preheated to make it combustible in engines.RMA, RMB, RMD, RME, RMG or RMK are the international trade names.

Benefits of HFO rental power plant:

- Minimum operating cost: Potential savings in the region of 20-34% (depending on the location of the installation) due to the lower cost of HFO compared to diesel.

- Fast track deployment: Multi-megawatt power plants can be installed in weeks. Aggreko's fleet located in over 190 strategic hubs around the globe, coupled with ease of transportation due to all equipment being housed in 20 foot containers, makes it easier to ship, install and commission the power plant in very short timescales anywhere in the world.

- Built in redundancy: Individual generating units of small capacity within the plant allow for optimum redundancy to be built in to the design of the power plant, thereby ensuring full power output is maintained even during maintenance periods.

- Flexibility: HFO based power plants have the flexibility to alter the plant capacity in small increments due to the smaller high speed engines, compared to medium / low speed engines which have a greater footprint.

- Minimal civil works: HFO based power plant installation eliminates the need for complex, costly and time consuming civil works that are otherwise required to install a permanent HFO power plant.
- Full turn-key service : The EPC contractor takes full responsibility for all phases of the service offering including the design, transportation, installation, commissioning, operation and maintenance - backed by more than 50 years providing rental power solutions.

Fig – 3.1- HFO based power plant.

Cheap, but challenging:

As a residual product, HFO is a relatively inexpensive fuel – it typically costs 30% less than distillate fuels (MDO/MGO). It thus became the standard fuel for large marine diesel engines during the oil crisis in the 1970s and 1980s, and it required extensive adaptation of the injection system and other components of low and medium speed engines – which are still the only reciprocating engines capable of running on HFO. Most of our MAN medium speed liquid fuel engines can burn heavy fuel oil (HFO). Of course, our medium speed dual fuel engines are capable of burning HFO in liquid fuel mode as well.

Table 3.1 : List of HFO based power plant Of Bangladesh.

SL NO	Name of the power plant	Name of the Authority	Fuel Type	Installed Capacity (MW)
01	Haripur NEPC	Pendeker Energy	HFO	110
02	Meghnaghat (IEL)	Orion	HFO	100
03	Madanganj (Summit)	Summit	HFO	102
04	Madanganj-55 MW	IPP	HFO	55
05	Keraniganj (Powerpac)	Powerpac	HFO	100
06	Siddhirganj (Dutch Bangla)	Orion	HFO	100
07	Gagnagar (Orion)	Orion	HFO	102
08	Katpotti 51 MW	IPP	HFO	51
09	Southern Power	RPP	HFO	55
10	CLCPC Keranigonj	IPP	HFO	108

11	Gazipur (RPCL)	RPLC	HFO	52
12	Raozan 25 MW (RPCL)	RPCL	HFO	25
13	Patenga 50MW (Barakatullah)	Barakatullah	HFO	50
14	Sikalbaha 225 MW	PDB	HFO	225
15	Sikalbaha Peaking GT	PDB	HFO	150
16	Sikalbaha (Energis)	RPP	HFO	51
17	Hathazari peaking	PDB	HFO	98
18	Dohazari-Kalaish Peaking	PDB	HFO	102
19	Juldah (Acorn)	QRPP	HFO	100
20	Chittagong ECPV 108 MW	IPP	HFO	108
21	Titas (Daudkandi) Peaking	PDB	HFO	52
22	Lakdhanvi-52 MW	IPP	HFO	52
23	Jamalpur IPP	IPP	HFO	95
24	Khulna (KPCL-2)	KPCL	HFO	115
25	Faridpur Peaking	PDB	HFO	54
26	Gopalganj Peaking	PDB	HFO	109
27	Noapara (Khanjahan Ali)	QRPP	HFO	40
28	Summit Barisal 110 MW	SUMMIT	HFO	110
29	Baghabari Peaking	PDB	HFO	52
30	Bera Peaking	PDB	HFO	71
31	Amnura	QRPP	HFO	50
32	Katakhali (Northern)	QRPP	HFO	50
33	Katakhali Peaking	PDB	HFO	50
34	Santahar Peaking	PDB	HFO	50
35	Rajlanka 52 MW	IPP	HFO	52
36	Chapainawabganj-100 MW	PDB	HFO	100
Total				2946 MW

Table 3.2 - Marine residual fuel Specification:

Parameter	Unit	Limit	RMA[a]	RMB	RMD	RME	RMG				RMK		
			10	30	80	180	180	380	500	700	380	500	700
Viscosity at 50°C	mm2/s	Max	10	30	80	180	180	380	500	700	380	500	700
Density at 15°C	Kg/m3	Max	920	960	975	991	991				1010		
Micro carbon Residue	% m/m	Max	2.5	10	14	15	18				20		
Aluminium+ Silicon	mg/kg	Max	25	40		50	60						
Sodium	mg/kg	Max	50	100		50	100						
Ash	% m/m	Max	0.0	0.070			0.100				0.150		

			40			
Vanadium	mg/kg	Max	50	150	350	450
CCAI	-	Max	850	860	870	
water	% V/V	Max	0.3	0.50		
Pour point (upper) [b], Summer	°C	Max	6	30		
Pour point (upper) [b], Winter	°C	Max	0	30		
Flash point	°C	Min	60			
Sulphur [c]	% m/m	Max	Statutory requirement.			
Total Sediment, aged	% m/m	Max	0.10			
Acid Number [e]	mgKOH/g	Max	2.5			
Used lubricating oils (ULO): Calcium and Zinc; or Calcium and Phosphorus	mg/kg	-	The fuel shall be free from ULO, and shall be considered to contain ULO when either one of the following conditions is met: Calcium > 30 and zinc >15; or Calcium > 30 and phosphorus > 15.			
Hydrogen sulphide [d]	mg/kg	Max	2.00			
a	This residual marine fuel grade is formerly DMC distillate under ISO 8217:2005.					
b	Purchasers shall ensure that this pour point is suitable for the equipment on board, especially in cold climates.					
c	The purchaser shall define the maximum sulphur content according to the relevant statutory requirements.					
d	Effective only from 1 July 2012.					
e	Strong acids are not acceptable, even at levels not detectable by the standard test methods for SAN. As acid numbers below the values stated in the table do not guarantee that the fuels are free from problems associated with the presence of acidic compounds, it is the responsibility of the supplier and the purchaser to agree upon an acceptable acid number.					

Chapter 4

Centralized power generation:

What Is a Centralized Organization?

A **centralized organization** is structured by a strict **hierarchy of authority** where most decisions are made at the top by one or a few individuals. Information from lower levels flows up to the decision-maker where the information is analyzed and synthesized to gain a broader perspective in order to aid in decision-making. Information flows down to provide directions to the lower levels of the hierarchy where lower levels are expected to implement the decisions with little or no modifications. Examples of organizations utilizing a centralized structure include the Bangladesh power development board, Bangladesh chemical industries corporation and large corporations.

Centralized HFO based power generation context of Bangladesh:

According to power purchase agreement (PPA) between PDB and IPP holders in 2008, PDB is responsible for supply of all required HFO to power plant owners. PDB must be ensure the “Guaranteed Net Flat Heat Rate” by the supplied furnace oil means that the guaranteed heat rate for the Term of the Project applicable for all load factors at Reference Site Condition submitted by the power plant owners in its tariff offer. If the power plant owners not able to generate power within their declared capacity, the entity will be encountered by liquidated damage to BPDB as per pre define rate. When IPP holders of HFO base power plants start commercial operation as per terms and conditions of agreement, they found that PDB supplied furnace oil not meet with the defined fuel specifications. As a result, PDB supplied fuel not produces specified heat rate and that effect on steam production. In the power generation cycle, furnace heat rate directly proportional to steam turbine efficiency and output power generation. After those power plant holders scrutinized the overall supply chain of HFO and find out that BPDB fuel supply chain is not able to maintain the quality of the oil because of bureaucracy system and their supply chain competency.

In the power purchase agreement of HFO based power plants in 2008 , only fuel supply was centralized others like, built, operate, and owned were decentralized. In 2015 independent power producers association jointly argued to Government to amendment of the power purchase agreement and they are interested to collect the required furnace oil as their own responsibility. As a result Government amends the PPA and ordered that IPP holders collect the furnace oil as per contract agreement.

The high lights of amended power purchase agreement are following:

The purpose of this Agreement is to establish the terms and conditions for the supply by the Company to BPDB and for the purchase by BPDB from the Company of Net Energy Output and to deliver and purchase Dependable Capacity, and the rights and obligations of the Parties in relation thereto. For this purpose, the Company will build, own, Commission, operate, insure, maintain the Facility in accordance with this Agreement and the Technical Limits.

Term of Agreement (a) This Agreement shall become effective upon execution and delivery hereof by the Parties and shall terminate fifteen (15) years after the Commercial Operations Date, unless extended or earlier terminated pursuant to the provisions of this Agreement.

DELIVERY & SUPPLY OF LIQUID FUEL

The Facility will be operated using HFO (furnace oil) as fuel. The liquid fuel (HFO) system shall include provisions of check metering facilities, on-line analysis facilities, heaters or other facilities required to treat HFO to meet the requirements of the reciprocating engine manufacturer. The Project Sponsor will arrange the supply and delivery to the site of required quantities HFO from any Fuel Supplier for use as fuel to the power generation facility. The Sponsor shall arrange necessary land and construct jetty/railway line on that land for fuel transportation upto the Project Site with the prior approval of relevant authority of the GOB. The fuel supply arrangements will be required to ensure an adequate and reliable supply of fuel. All arrangement required for supply of liquid fuel to the Facility including construction of jetty (if required), necessary arrangement in the nearest railway station, pipe line upto the Company's storage facility, fuel measuring system, internal fuel supply system, fuel heating and purification/treatment system as per requirement of the offered plant shall be installed by the Company at its own cost and responsibility. The Company will obtain the necessary right of way for the pipelines up to the Company's storage facility.

Fuel (furnace oil) storage facility for operating the plant for at least 15 days continuously at 80% plant factor shall be constructed by the company at its own cost before COD and the company shall maintain this stock of fuel for all time thorough out the contract. If the Company is unable to deliver electricity in accordance with the Dispatch Instruction due to inadequacy of fuel, the Facility will be treated as fully or partially unavailable depending on the shortage of Dispatch, which affect the Availability.

“Fuel Supply Agreement (FSA)” **–** means the agreement or agreements to be entered into by and between the Fuel Supplier and the Company for the supply of liquid fuel to the Facility.

According to IPP cell Director of BPDB, the advantages and disadvantages of centralized HFO based power generation in Bangladesh are following:

Since the 2008s, electricity production in Bangladesh has been driven towards generation concentration and a higher degree of integration leading to the current centralized electricity paradigm. This move was driven by several factors:

Lower power generation cost: when the increase of generation of centralized HFO based power , the production cost will be reduced proportionally. The procurement cost of fuel, accessories & spare parts reduced dramatically because of economies of scale.

Increase the produced energy efficiency: If HFO based power plants operate centrally, the high pressure & temperatures used in large stream turbine that will increase the overall plant efficiency. The power plants will be considered as base load power plant and multidimensional experts perform there.

Enhance knowledge management by lesson learning: Centralized HFO based power plants enhance employee learning curve by sharing knowledge each other. Different plants encountered different technical problems so they can convert their knowledge explicit to tacit, tacit to tacit, tacit to explicit , which will help others same type troubleshooting.

Reliable transmission system: Centralized power generation enhance the long distances transmission competency because the frequency adjustment situation or reactive power generation. Centralized power generation play a vital role to ensure reliable & quality power to customer.The transmission system losses also reduced by centralized power generation.

The search for reliability: so as to increase the reliability at the customer's end, large electricity production facilities were connected to the transmission networks. Pooling resources helped reduce the reliance of each customer on a particular generator as other generators were often able to compensate for the loss.

Environmental constraints: the use of transmission networks made it possible to relocate the generation facilities outside the city centers thus removing pollution due to exhaust from power plants chimney.

Though dominant, centralized generation has always been operating along a smaller distributed generation capacities that were never phased out of the market. The persistence of the first historical form of energy generation whereby energy is consumed near its generation point seems puzzling in the light of the properties of centralized generation mentioned above. The significant size of distributed generation in Bangladesh clearly implies that it is capable of overcoming shortfalls of the centralized generation paradigm.

Disadvantages

The main drawbacks of the centralized HFO based power generation:

Several studies were conducted to emphasize the main shortfalls of the centralized generation paradigm and to explicit the motivation of the agents in keeping distributed generation as a primary source of electricity or as a backup generator.

The main drivers listed in the literature are summarized below:

Transmission and distribution costs: The industrial consumers & commercial consumers are situated in discrete positions. So, transmission and distribution cost will be reduce if the power plants build in customer premises. Transmission and distribution costs amount for up to 30% of the cost of delivered electricity on average.

The high price for transmission and distribution results mainly from losses made up of:

System losses: electricity is lost when flowing into the transmission and distribution lines.conversion losses when the characteristics of the power flow is changed to fit the specifications of the network (e.g. changing the voltage while flowing from the transmission network to the distribution network) .

Back up generation: the main use of distributed HFO based power generation is for back up capacities to prevent operational failures in case of grid fail problems. Backup generators have been installed at critical location such as industrial area, cantonment, hospitals and other key point installations.

Chapter 5

What is Decentralized organization and how does it work:

As the name suggests, a decentralized organization is one where the decision making authority is not solely in the hands of a particular group or figure but with multiple people at multiple levels of the hierarchy. In this type of an organization, most of the decisions are made by middle level or lower level employees rather than being made by the top management, as is the case with centralized organizations.

The main characteristics of distributed generation

The main drivers behind the revival of distributed HFO based power generation:

Bangladesh Government distributed HFO base power generation policy reduce the entry barrier and clearer prices signals. Distributed generators are able to move in niche markets and exploit failures of centralized generation. These new applications took the form of standby capacity generators, peaking generators .That power plant improving reliability and power capacities, generators providing a cheaper alternative to network use or expansion, provision of grid support.

The IPP power plants tend to be of smaller size and quicker to build; they have been able to benefit from price premiums. Geographical and operational flexibility made it possible to set up distributed generators in congested areas or use it only during consumption peaks. Besides, for small excess demand, it is often uneconomical to build an additional centralized generation plant whereas with lower CAPEX and capacities, distributed generation might become convenient.

The second driver behind the rebirth of distributed HFO based power generation is to be related to environmental constraints. Environmental and economic constraints led to look for cleaner and more efficient use of energy.

According to owner of HFO based Independent power producers:

The Main challenges to be faced while increasing the share of distributed generation.

To sustain the forecast penetration rate, the architecture of the electricity sectors needs to be altered. The current infrastructures were not originally built to accommodate a large proportion of distributed generation. For the moment, only necessary adjustments are undertaken in order to accommodate these new capacities.

Technical constraints:

The first difficulties to overcome are related to technical improvements necessary to ensure high system reliability with distributed generation. The following section gives an overview of the technical issues caused by distributed generation. The classification and description are derived from a study by Pehnt and Schneider (2006). The issues can be classified as follows:

Capacity: adding distributed generators at the distribution level can significantly impact the amount of power to be handled by the equipment (cables, lines, and transformers). In order to avoid overload problems, reinforcement work will have to be undertaken. As shown by Pehnt and Schneider, the critical piece will often be the transformers (converting medium voltage to low voltage or high voltage to medium voltage): if power generated exceeds by far consumption, power will have to flow back from the low voltage network to the medium voltage network or from the medium to the high voltage network and be directed to other consumption areas. The transformer will have to be able to handle this reverse flow i.e. being able to convert it back and have specification to cope with potential oversupply. This is of major issue at peak hours: at that time both continuous and peaking distributed generators will operate to cash in the price premium. Production forecast from peaking distributed generators is key while determining the specifications of the equipment, as capacities will be added when the total power flow is already significant.

Voltage: Power plants are often generate 11KV and converted that voltage 132KV or 230KV as per connected grid network voltage level. High voltage level is mandatory for long distance transmission. How many power plants are connected in a particular area & their power generation capacity define by regulated authority to minimize the power over voltage or under voltage fluctuation.

Protection: Additional protection strategy is required to protect the power plant from technical hazards. Distributed power plants are vulnerable about frequency & voltage fluctuations as well as over current , earth faults. So, some special protection system could save from unnecessary tripping & continuity the generation process. Protection system also a primary risk management tools not only protect the equipment’s but also protect the staffs.

Voltage and current transients: The distributed generators are responsible for short term frequency fluctuation because of plants switched on or off. That type of disturbance has an impact on partial or national grid fail of whole network.

Transmission and distribution losses: The transmission & distribution losses reduced by distributed power generation because power plants established near to consumer as a result short transmission & distribution length is required. Some captive power plants are not connected with national grid , they feed the power directly distribution network in their premises.

Ancillary Services: Asof today all the ancillary services positively impacting the quality of electricity delivered are provided by centralized generators. For example, centralized generators are requested to keep capacities in excess of peak load to adjust production in case of demand surge, to hold voltage control devices. As the share of distributed generation increases, distributed generators will have to provide a larger share of these services. In addition to the technical issues mentioned above, two fields of research will have to be further investigated: “active” network and “virtual power plants” and micro grids.

In a high sophisticated transmission network system the adjacent power plants should be cope with all technical requirements otherwise it will be impacted negatively in whole power system. Distributed power plants construction cost rise because of coordination, communication, supervisory controlling system & data acquisition and so on. In smart grid network the cost rise more & more than conventional grid system. All distributed power plants mandatory to follow the grid code & all international standards.

Cost competitiveness: the economics of distributed HFO based power generation

One key hurdle to overcome in a deregulated power market is the cost competitiveness of distributed generation. This parameter varies, however, a lot from one technology to the other mainly. One of the main reasons for such a difference is the age of the technology and its current state of development. For example reciprocating engines have been used for decades and are a mature technology while fuel cells are still subject to significant research and development in order to become a credible source of generation.

Planning: one of the main benefits of distributed generation is to defer costly investments in distribution networks by producing electricity where it is most needed. Though cost effective, these economies are often not realized due to the structure of the revenues of the distribution network operators. As regulated natural monopolies, distribution network operators are often remunerated on a cost plus of rate of return basis with adjustment for reaching performance tests. This structure gives them little interest in favoring distributed generation as they do not directly benefit from this improvement: operators will choose to invest in the costly solution that gives them a safe income instead of a less costly solution with no gain. This is even more pronounced as since the electricity market deregulation, transmission network operators cannot hold generating capacities. In some countries, regulation has been adapted to take into account this potential cost reduction.

Incremental distribution costs caused by distributed generation: though in the long run distributed generation defers investment in the network, reinforcement work has to be undertaken to accommodate this new form of generation. This additional distribution costs (incremental CAPEX and OPEX) caused by distributed generation is seldom accounted for in the current compensation of network operators. Operators are thus less inclined to favor this option.

Energy losses: the treatment of energy losses varies greatly across countries. With a low penetration rate and low concentration, distributed generation has a positive impact on these losses. Regulation on this specific point affects the profitability of the distributed generators. The network operator thus has a financial gain in letting distributed generators enter the market and reduce this amount of losses. This is however less advantageous to the centralized generators. The adoption of such solution will thus be significantly affected by the relationship between centralized generators and network operators. When both, though legally independent from one to the other, are owned by the same entity, the operator might not be willing to favor the distributed generators.

Ancillary services: Peaking power plants only generate power when it is required at peak hour otherwise the plants shutdown. Some powers plants operate only operate as a voltage control device.

Incentives for innovation: Integrated HFO based distributed power generators into the grid network system will trigger a rapid change in the management and load dispatch control process. Distributed generations can play a vital role for the replacement of traditional grids by smart grid.The results of the regulatory incentives given for innovation is mixed.

Chapter 6

Developing supply chain capability by centralized HFO based power generation: According to management theorists centralized organizations enhance the competency & capability of strategic supply chain by different ways. Technical experts of centralized organization benefited by lesson learning and knowledge management. Every technical trouble shooting gained knowledge & technical persons can propagate the knowledge to other power plant employees. That will help to develop a knowledge bank regarding HFO based power plant common issues. Total quality management ensure by incremental change.

Knowledge management: Systems to capture & share individual & group knowledge and learning are increasingly recognized as important, so that every member of an organization or wider supply chain can contribute to the creation management & dissemination of collective knowledge. The objective of knowledge management is to optimize the knowledge that is available in an organization and supply chain: creating new knowledge, and increasing awareness and understanding in the process.

Knowledge management may be defined as the systematic process that supports the continuous development of individual, group & organizational learning; involving the creation, acquisition, gathering, transforming, transfer & application of knowledge to achieve organizational objectives.

Management guru **Mullins** states that knowledge management both with organizational learning and with the ability of the organization to make effective use of its intellectual assets. Learning is a core competitive competency for an organization, and knowledge a core competitive asset. Knowledge and learning gained through developing products and processes, monitoring and reviewing projects etc should be captured and exploited not wasted, or lost to the organization or supply chain over time.

A systematic approach to knowledge management:

A systematic approach to knowledge management involves the following processes.

- Acquiring knowledge from environmental scanning, market research, procurement research, benchmarking, modeling, networking and so on.
- Generating or creating knowledge, through processes such as ideas generation:; research &development ;stakeholder consultation; lesson learning and cultivating supplier & workforce diversity.
- Transforming information into new knowledge by compiling, combining, analyzing, interpreting or re formatting.
- Capturing unspoken, internal (tacit) knowledge to convert it to open, stated (explicit) knowledge, so that it can be communicated, shared & used.

- Organizing knowledge: categorizing, grouping and indexing information to facilitate easy retrieval and use.
- Storing knowledge effectively in information and knowledge management systems.
- Sharing or dissemination knowledge throughout the organization via ICT networks, cross functional teams, communities of practice ,networking ,training and education activities and so on.
- Maintaining knowledge: updating documents to ensure that they reflect current knowledge and practices and archiving or purging out of date documents.
- Protecting distinctive, value adding knowledge for competitive advantage via access controls, confidentiality agreements and intellectual property protections.
- Applying knowledge to develop core capabilities which cannot easily be imitated by competitors.

knowledge Management in occupational psychologist **MP Kerr** identifies seven drivers for systematic knowledge management in organizations.

- Business pressure in innovation.
- Inter organizational enterprises
- Networked organizations and the need to co-ordinate geographically dispersed groups.
- Increasingly complex products and services with a significant knowledge component.
- Hyper competitive global markets.
- The digitization of business environments and the ICT revolution.
- Concerns about the loss of organizational knowledge, due to increasing downsizing, outsourcing and staff mobility.

Capturing & utilizing knowledge:

Ikujiro Nonaka argues that organizational learning results from a process in which individual knowledge is transferred, enlarged and shared upwardly to the organizational level. In collaboration with Hirotaka Takeuchi, Nonaka developed this idea into a model based on the distinction between tacit & explicit knowledge.

- Tacit knowledge is innate ‘how know’: deeply ingrained, taken for granted and often unconscious mental models and competencies. People just know how to do things. Such knowledge is difficult to articulate, formalize or share with others.
- Explicit knowledge is formal, systematic, clearly articulated knowledge, which can be communicated and shared via tools such as product specifications, procedures or computer programs.

  To increase organizational learning, a process of knowledge conversion is required, beginning at the individual level, and expanding through social interactions to include a diversity of perspectives that ultimately represent shared knowledge at the organizational level. Nonaka and Takeuchi illustrate this process.

Socialization From tacit to tacit Sharing experiences, mental models and skills	Externalization From tacit to explicit Articulating tacit knowledge into concepts
Internalization From explicit to tacit Embodying explicit knowledge into tacit knowledge	Combination From explicit to explicit Systemizing concepts into known systems

Fig: Nonaka – Taguchi knowledge management cycle.

Knowledge communities & communities of practice:

A knowledge community is a group of individuals or organizations with a common interest, and a willingness to share ideas and experience. A knowledge community may exist within a single organization. For example, the might be an area on the firm's intranet where different project teams could swap tips or request help from others who have met with similar problems in the past.

Alternatively, a knowledge community could involve a wide range of individuals and organizations, facilitated by ICT networks such as the internet. The term communities of practice is often given to groups of people drawn together to facilitate learning and best practice sharing other than with immediate work colleagues. They are usually organized around a particular theme, field or knowledge domain, with in learning and knowledge development with a shared knowledge domain.

Chapter – 7

Conclusion

In conclusion I would like to restate that centralized HFO based power generation increase the efficiency of overall power generation of Bangladesh. As a limited natural resources country we should follow 4R- recycle, reuse, reduce and recover. Furnace oil itself a recycling product of mineral oil. In HFO based centralized power plant we can reuse the exhaust steam and reduce input fuel. Bangladesh is a middle earner country and we need to continuous improvement day by day in power generation sector for a sustainable power flow over the country. Centralized organizations reduce the stock level of spare parts, fuel and manpower. For overhauling purpose centralized power generation overcome the load shedding problem because unit by unit can be shut downed. Also, centralized power generation enhance the core competency of fuel supply chain. Centralized power plants considered as a base load power plant and the overall system is act as a sustainable power flow.

However, there are many investors of IPP power plant reject the above notions. They have a set of reasons in favor of their statement. The main constraint to the build of a power plant is primary investment. So, in a distributed power plant required less investment than a centralized power plant. Investors easily manage the preliminary finance which is bit difficult to construct a large power plant. Different investors have different type of policy and they can apply their idea independently when they invest their money in this sector. HFO based power plants fuel supply chain is depending on logistics & transport. So, it is a challenge for any regulatory agency like BPDB to perform a sophisticated plain supply chain regarding fuel supply. Political unrest, trade union of respective transportation system, stock, store management, operational management all are different constraint of fuel supply chain and that can be a challenge of execution authority. But in distributed approach, power plant owners maintain separate supply chain as their other business. Distributed power plants independently operate their plant & they are not coupling with other power plant or unit which gives them competitive advantage regarding decision making time. Their profit or losses not impact other power producer.

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