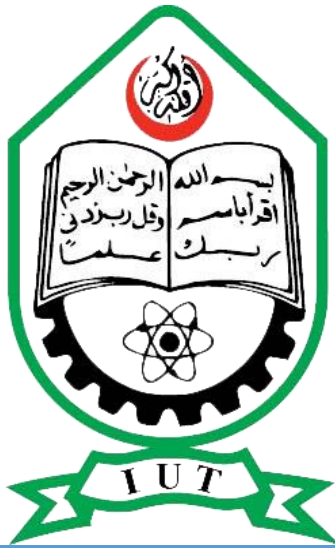

Application of Modern Supply Chain Management Tools to Power Plants of Bangladesh: A Case Study

Supervised By
Dr. A.R.M Harunur Rashid

Authors
ASIF MAHMUD (131406)
MD. MOINUL HOSSAIN (131412)

Department of Mechanical and Chemical Engineering (MCE)
Islamic University of Technology (IUT)
Organization of Islamic Cooperation (OIC)

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ABSTRACT

Power generation sector of a country plays a pivotal role in her overall development and progress. In modern world, as days goes by people are getting depended on technology even more. Bangladesh is the ninth most populous country in the world. In order to turn this overpopulation from a burden to a blessing we need to equip them with necessary technology. To provide technology for this huge amount of people we need a lot of electric power.

If we take a look at the most developed countries in the world like USA, CHINA, JAPAN etc. they are also the country which are leading in electricity production. It clearly proves how much impact energy production has on any country's development. This is where Bangladesh lacks the most. Our country currently ranks 46th in overall electricity production whereas its population ranking is 9th in the whole world.

The first idea that comes to our mind in order to increase our country's overall electricity production is to establish new power plants. But it is a very hazardous, costly, environmentally polluted process. So, it's clearly not an easy process. There is another thing we can do to increase the electricity production. Electricity production in a power plant is a very complicated and lengthy process integrated with a lot of delicate work to do which keeps a room for improvement in the overall management sector.

Modern supply chain tools are currently being used in pretty much every managing sector due to its radical effect. Utilizing it in our power sector can also help in increasing the overall efficiency. It is a relatively new concept in our country. But there are countries around the world using modern supply chain in their power plants and getting positive feedback. Our thesis is a case study about the prospect and goals that can be achieved if modern supply chain tools are applied in power plants of Bangladesh.

DECLARATION

This is to declare that the project **"Application of Modern Supply Chain Management Tools to Power Plants of Bangladesh: A Case Study"** and related audit were carried out by the authors under the supervision of Asst. Prof. Dr. A.R.M. Harunur Rashid, Department of Mechanical and Chemical Engineering, Islamic University of Technology (IUT).

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Asst. Prof. Dr. A.R.M. Harunur Rashid

Department of Mechanical and Chemical Engineering

Islamic University of Technology (IUT)

_____ _____

Asif Mahmud

Student ID- 131406

Phone- +8801717764540

Md. Moinul Hossain

Student ID- 131412

Phone- +8801521439400

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ACRONYMS

SCM: Supply Chain Management

BPDB: Bangladesh Power Development Board

SKU: Stock Keeping Unit

O&M: Operation and Maintenance

FMCG: Fast Moving Consumer Goods

HFO: Heavy Fuel Oil

CHAPTER ONE

INTRODUCTION

Bangladesh being one of the fastest growing economy and a promising developing country in the world, its power demand is ever increasing. In this modern age, a country's power producing capacity is an index of its development. We can see it by the high power producing rate of the developed countries.

Even though we have increased our capacity in recent years like even in 90's our only power producing options were KARNAPHULI POWERPLANT only producing 200 MW which increased to 7000 MW (approx.) up to today. But with the increase use of modern gadgets, machineries and everything it is still not sufficient.

To increase power capacity we need to establish new power plants and increase the efficiency of the existing one. Since establishing a new power plants is a really tough job considering its expenses, environmental hazards, raw material transport problems, we need to concentrate more on increasing the efficiency on the existing one.

Background

BPDB is the power generation and supplying authority of Bangladesh run by the Government of People's Republic of Bangladesh. It has been working diligently to serve the people of Bangladesh since its inception.

But with the passage of time and improvement of socio-economic condition of the country the scope of work also increased. This boom in power demand came with a lots of challenges for BPDB, not only in generation but also in infrastructure realignment. The power plants operate at their peak efficiency i.e. there is almost no scope to increase the rated capacities of the units. But developing and streamlining the infrastructure and plant management can reduce lead times and result in cutting down overall per unit generation cost. Focusing on reducing various system losses in the process by applying modern Supply Chain Management Tools can have positive impact on the power sector.

Status Quo

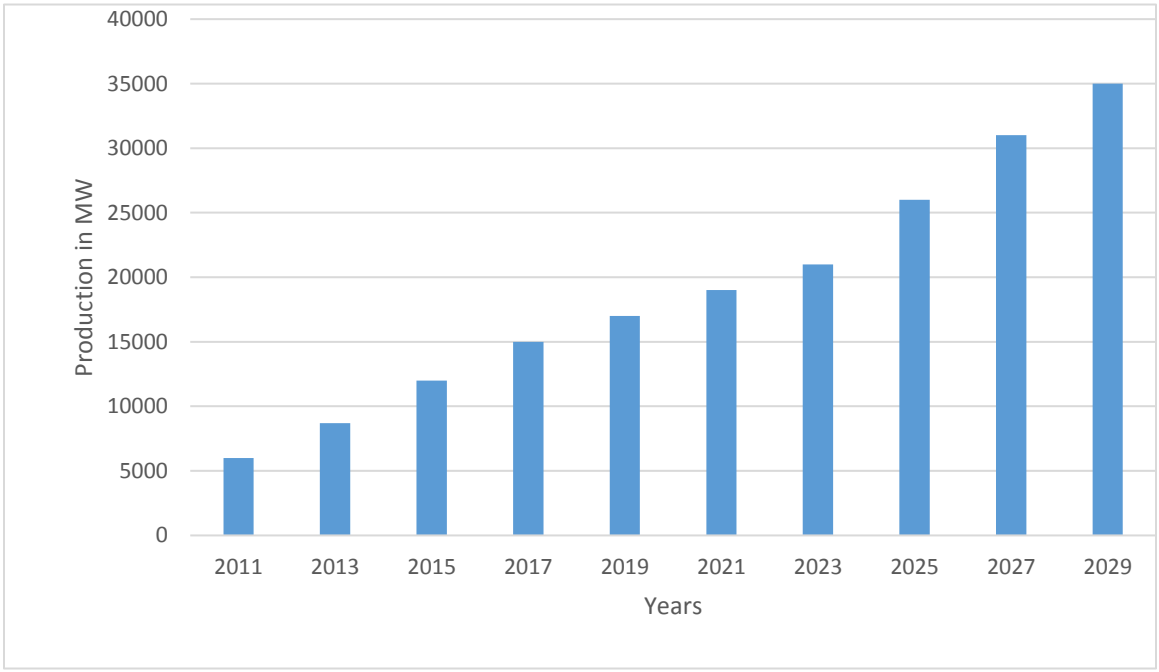
Total power generation capacity in Bangladesh up to May 2017

Source: BPDB (Bangladesh Power Development Board)

FUEL TYPE	Installed Capacity	Total (%)	Derated Capacity	Total (%)
COAL	250.00MW	1.9%	200.00 MW	1.59 %
GAS	8267.00 MW	62.73 %	7844.00 MW	62.36%
HFO	2800.00 MW	21.25%	2743.00 MW	21.81%
HSD	1032.00 MW	7.83%	961.00 MW	7.64%
HYDRO	230.00 MW	1.75%	230.00 MW	1.83%
IMPORTED	600.00 MW	4.55 %	600.00 MW	4.77%

Challenges

Our electricity demand is going to increase each day progresses. This is an estimate according to BPDB about the increasing demand in upcoming years.



If we closely take a look at the graph we can see that, while the demand was only 10000 MW in the year 2015 it will approximately increase up to 30000 MW within 2028. We can see the exponential increase of electricity demand in our country with time. But unfortunately our energy resources will not increase with the same rate.

This isn't the only problem and challenges we are facing. Bangladesh's total energy production is highly dependent on natural gases. In order to protect the gas reserve government turning the gas driven power plants into duel fuel power plant. It leads to a less economic system.

There is also an environmental factor to consider. We are the most densely populated country in the whole world. Establishing power plants needs a huge amount of space. It is highly unlikely to find a suitable place to establish a new power plant without having human residence nearby.

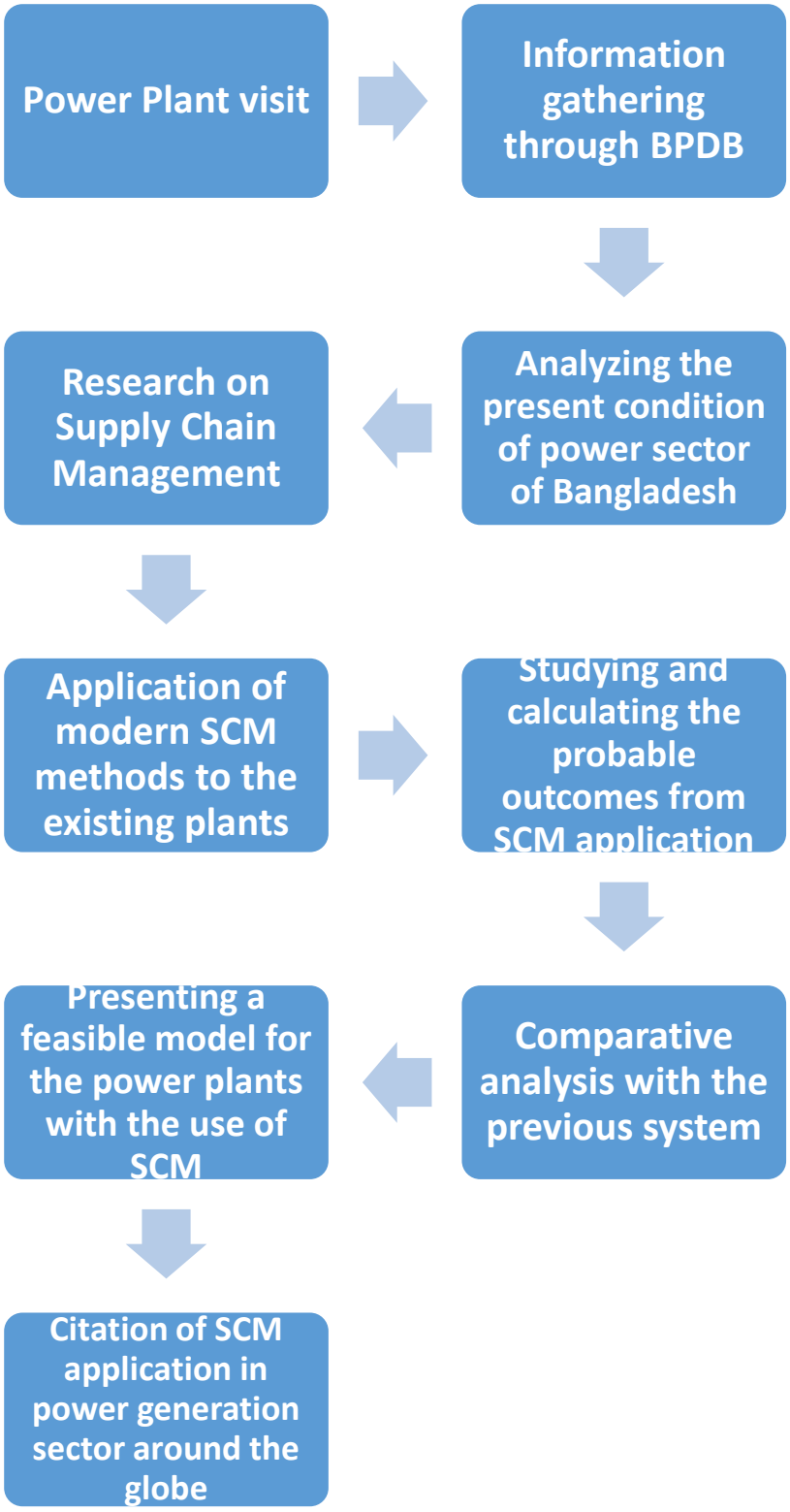
Objectives of the Study

We have conduct our study keeping some targets ahead. We wanted to achieve these goals through our study. Some of the primary objectives of our study is given below –

- To show the current and upcoming challenges our power sector will face in future.
- To show the impacts of Supply chain management in any managerial sector.
- To assess the scopes of application of Supply Chain Management (SCM) to power plants in Bangladesh.
- We aim to look at the managerial sector and understand what application of proper supply chain management system can be improved.
- To find out the prospective advantages of applying SCM to this sector.
- We also target to establish a comparative study about this method.

CHAPTER TWO

RESEARCH METHODOLOGY



CHAPTER THREE

FIELDWORK

Our study was conducted through first hand data collection. We visited several power plants and collected data from primary source mostly. So, fieldwork and visits constitutes a huge portion of our study and gave us a clear perception of the existing power sector of our country so we can find out how to improve it.

Power Plant Visits

We were fortunate to visit 5 Power Plants in total to collect and observe data and day to day operations. All of these plants were operated by BPDB and its personnel. As most of these site are designated as KPI's we had to go through a number of security measures and verifications in order to gain access.

Karnaphuli Hydro Power Station

Karnaphuli hydro-electric power plant is the first power plant of our country situated in Kaptai, Rangamati. Due to costly, complicated, environmentally dependent process till date this is the only Hydro-electric power plant in our country. Some basic information about this power plants are given below-

Establishment: 1962

Location: Kaptai, Rangamati

Total Units: 5

Maximum Capacity: 242 MW

Turbine: Kaplan Turbine (Reaction Type)

Efficiency: 99 %

Supply Chain Management: Absent

Figure 1: Karnaphuli Hydro-electric Power Plant

Shikalbaha Power Station

Shikalbaha power station is situated at Shikalbaha not so far from the port city Chittagong. It has two different sets of power plants.

i) Gas Turbine power plant (150 MW)
ii) Steam turbine power plant (60 MW)

Some of the special features of this power plants are given below-

- Manufacturer : Siemens, Germany.
- Rated Power : 181 MVA / 144.846 MW (at 35 deg cen, 1.013 bar)
- Fuel : Natural gas
- Fuel cost /KWH : 1.01 Tk
- Efficiency : 33 %
- Time for full Load : 18.5 min
- Supply Chain Management : Absent

Figure 2: Shikalbaha Power Station

Chittagong Power Station

Chittagong power station is also known as “Raozan Power Station”. It is situated at 25 Km north-east of Chittagong. Here are some of its highlighted features-

Number of Units	: 02
Installation Capacity	: 2X 210 Megawatt per Unit
Total	: 420 Megawatt
Area	: 100.1 Acres
Raw Materials	: Water, Natural Gas, Air
Supply Chain Management	: Absent

Figure 3: Chittagong Power Station (Turbines)

Hathazari Peaking Power Plant

Hathazari peaking power plant is a relatively new power plant established in 2012 in Hathazari, near Chittagong. A peaking power plant is generally run only when there is a high demand (peak demand) for electricity. A peaking power plant generally has two primary functions-

- Peak hour supply: Supplying electricity during the peak hours of the day i.e. the time of day when the demand for electricity is the highest.
- To act as a reserve power: Peaking power plants in developed countries are used as a reserve supply to always keep the electricity fed. There are three types of such backup plants.
    - Primary reserve: Spinning mode, respond within 5s, get synchronized within 30-60s
    - Secondary reserve: Non-spinning mode, respond within 30s depending on stations, get synchronized within 5-10 mins. Also, it is remotely controlled.
    - Tertiary reserve: Non-spinning mode, mobile operator operates after getting a call.

Some special features of Hathazari Peaking power plants are given –

- Each engine has a rated capacity of 8.294 MW
- It is run by 11 HFO or diesel powered engines.
- All 11 HFO/diesel engines provide about 100MW with a 15% variation
- It is run after 5PM for about 4-5 hours during winter.
- Supply Chain Management : Absent

Figure 4: Diesel Engine Components

TONGI 80 MW GAS TURBINE POWER STATION

This is the only power plant we visited in Dhaka. Despite its name says 80 MW, it has an installation capacity of 105 MW.

- Rated Power : 105 MW (at 35 deg cen , 1.013 bar)
- Fuel : Natural Gas
- Type Of turbine : Gas turbine
- Number of stages : 03
- RPM : 3000
- Efficiency : 34 %
- Supply Chain Management : Absent
- 60 % energy used to run the compressor and rest to produce electricity.

Figure 5: Tongi 80MW Power Plant

Observation

- All the plants lagged any type of definite supply chain apparatus that are generally used in any management system.
- The existing supply chain was not even recognized as Supply Chain in the visited power plants. It was simply a series of process without proper co-ordination.
- Inventory management is one of the major components in any production system. None of the plants maintained proper rules of inventory management.
- There was no dedicated supply chain manager to control the whole process which ultimately leads to inefficient system
- Time consuming procurement system hindering inventory management.

CHAPTER FOUR

SUPPLY CHAIN MANAGEMENT

Definition

The entire oversight of the processes that include procurement, production, distribution and feedback is called Supply Chain Management. In a nutshell. Everything related to the product fall under the purview of Supply Chain. It encompasses planning and management of all stages that are involved directly or indirectly in accomplishing the customer needs. More importantly, it includes collaboration and co-ordination with partners, intermediaries, suppliers, customers and service providers.

Supply Chain Management Tools

SCM, as an invigorating part of enterprise resource planning, offers a number of tools at one's disposal. Utilizing these tools and factors properly optimizes and makes the entire process more efficient. Which in turn makes the company cost effective and profitable. Following are some such tools-

I. Internal Realignment
II. Category Management
III. Supplier Integration
IV. Risk Management
V. Inventory Optimization
VI. Improved Metrics

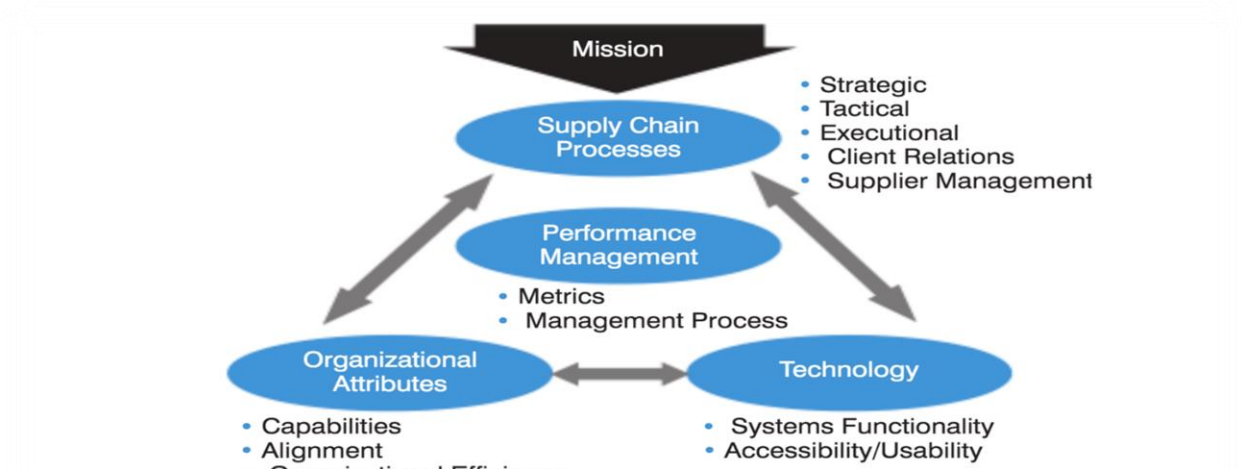


Figure 6: Typical SCM Process

Source: The Future of Utility Supply Chain Management, Thomas W. Overton, JD

Utilities Supply Chain Management

According to the Author of 'Optimal Supply Chain Management in Oil, Gas and Power Generation',

"Supply Chain Management in oil, gas and power generation closely resembles the process industry just more complex and dynamic in nature. Technology, even chemistry can affect every component and every decision due to vulnerable nature of its demand"

The supply chain agenda at leading utilities has evolved largely in recent years. The original focus on cost savings and organizational efficiency has changed, with increases in activity across all utility sectors, to encompass the challenges of cost constriction, supply assurance and risk management. At many utilities, however, the strategic role of supply chain management has not kept up with these recent challenges. For these utilities, the situation requires a complete overhaul of the SCM's role and a revamping of the supporting operating model.

As the utilities sector entered the last decade of 21st century, impending deregulation and increased scrutiny from regulators raised utilities' focus on cost management. This change brought a proliferation of strategic sourcing schemes made to reduce the costs of procured materials and services. Utilities coordinated cross-functional commodity groups to pursue more effective supplier strategies, reducing the number of suppliers on many commodities so that companies could grow stronger relationships with fewer, more essential suppliers. Utilities signed long-term corporate contracts for many spending groups, which redesigned the competitive landscape as weaker suppliers lost business and consolidated.

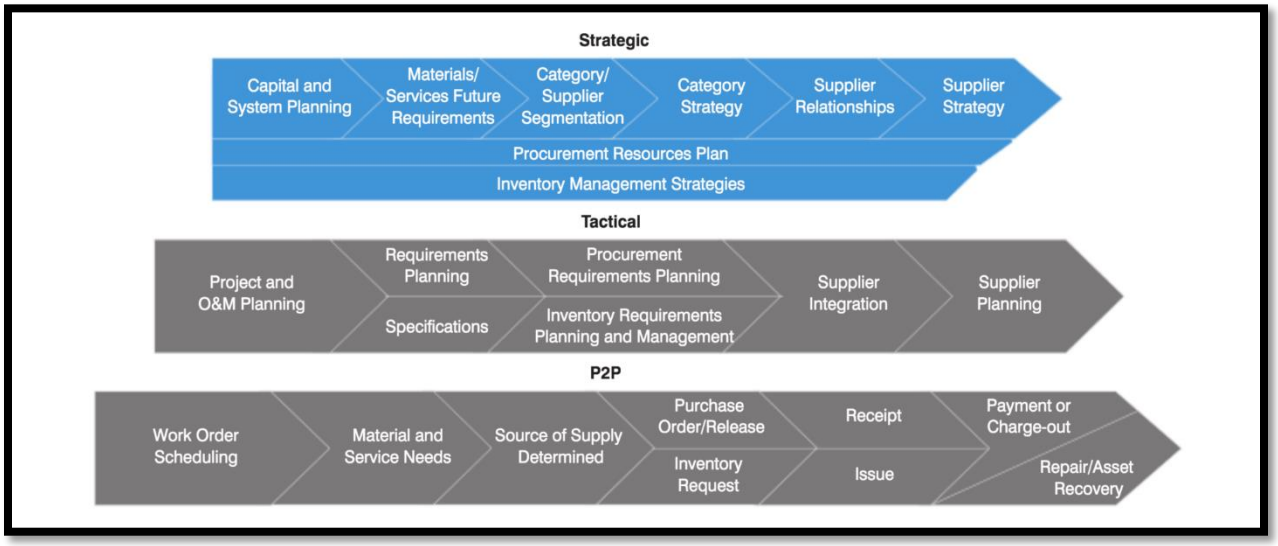


Figure 7: Utilities SCM Flow Diagram

Source: The Future of Utility Supply Chain Management, Thomas W. Overton, JD

After that, with the millennium upgrades and the dot-com boom, new technologies promised to revolutionize purchasing: enterprise-wide systems, Web-based exchanges. On the way, utilities' purchasing departments evolved into today's supply chain management function.

Many corporations got huge savings as a result of such programs. The primary strategic sourcing efforts yielded cost cuts averaging 10 to 15 percent. Furthermore, reverse auctioneers touted savings of as much as 35 percent on a variety of spending categories. SCM's strategic role as an arbiter of cost reduction was firmly established in utilities.

SCM's function in reducing costs and increasing efficiency was further cemented during the post-Enron years, when energy companies focused on getting back to basics. Operations and maintenance (O&M) budgets in the industry were trimmed and capital spending was restrained, which reinforced SCM's role in negotiating with suppliers on lower prices to help stretch what could be done with limited funds.

Supply chain forums designed their operating models to reinforce their goals corresponding to cost reduction and efficiency. Annual supplier negotiations were conducted by people schooled in "putting the vendor in his place" by ensuring that the utility's cost reduction targets must be met "or else." Organizations and processes were streamlined to process a routine flow of requisitions and orders. Systems investments were focused mainly on more streamlining and reducing the costs of these transactional activities. Unfortunately, the depletion in gross activity and cost focus also led to staff reductions in many utility SCM organizations, resulting in the loss of experienced resources. These people are now sorely missed as SCM organizations try to keep pace with the ramp-up in spending over the last few years.

Distinguishing SCM in Power Sector

Majority of people understand SCM from the consumer product industry's perception, where thousands of SKUs of FMCG flow through distribution centers. SCM in power sector resembles more to the process industry. Even so, it is much more complex than in low value process industries like paper and cement. Technology, chemistry etc. affect every steps, decision, starting from procurement to designing network, installation and logistics. This complexity shows itself in most segments of the business as such in power sector, advances in materials sciences are allowing the turbine temperatures to surpass 2200 (Deg.F), delivering more power.

The prohibitive cost of downtime makes reliability and field responsiveness critical. Long investment cycle should consider risk and uncertainty factors.

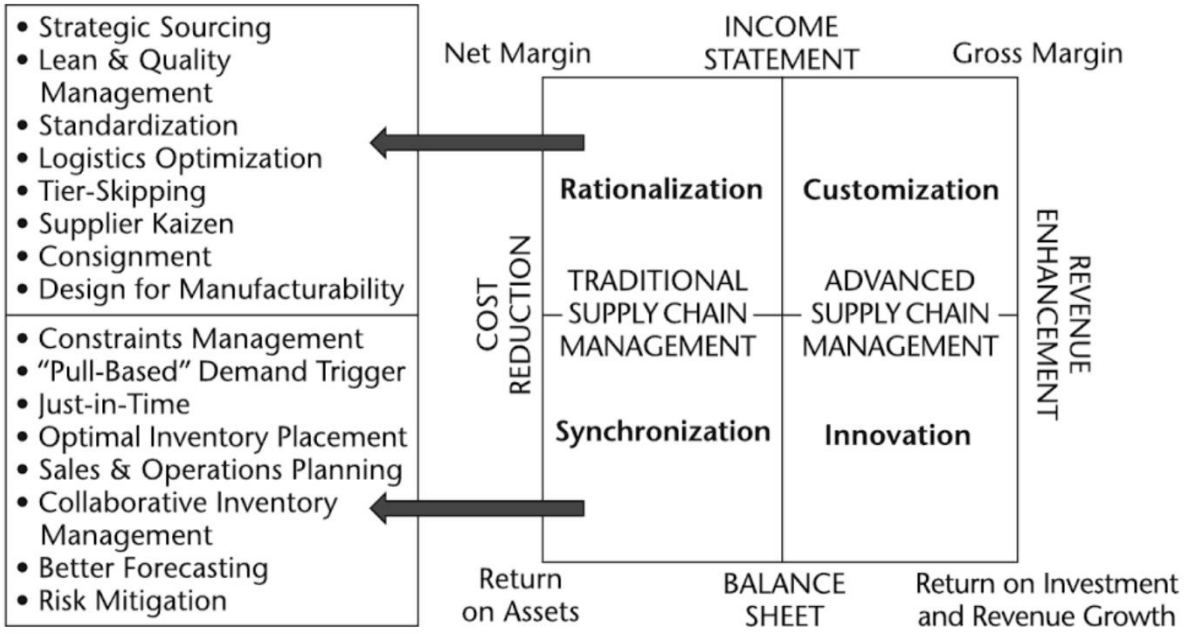


Figure 8: SCM Strategies for Power Sector

Source: Optimal Supply Chain Management in Oil, Gas, And Power Generation- David Jacoby

The above figure depicts how SCM can impact the power sector. It shows the schemes for increasing profit margin or in other words cost reduction. Optimization requires all the factors to be in sync and proper application.

Key Supply Chain Processes

Usual cross industry SCM processes include manufacturing and distribution site, location, strategic sourcing, demand forecasting, inbound logistics, transportation etc. But, the elements of SCM strategy for power companies are asset intensive, thus many of their core business processes have to deal with asset procurement, deployment etc. Mapping most typical SCM techniques to the business processes that are more relevant to power sector. Dismembering this integrated framework gives us three important topic areas-

1. Capex project supply chain risk mitigation
2. Engineering and procurement of equipment and services at minimum cost and risk
3. Operating cost minimization

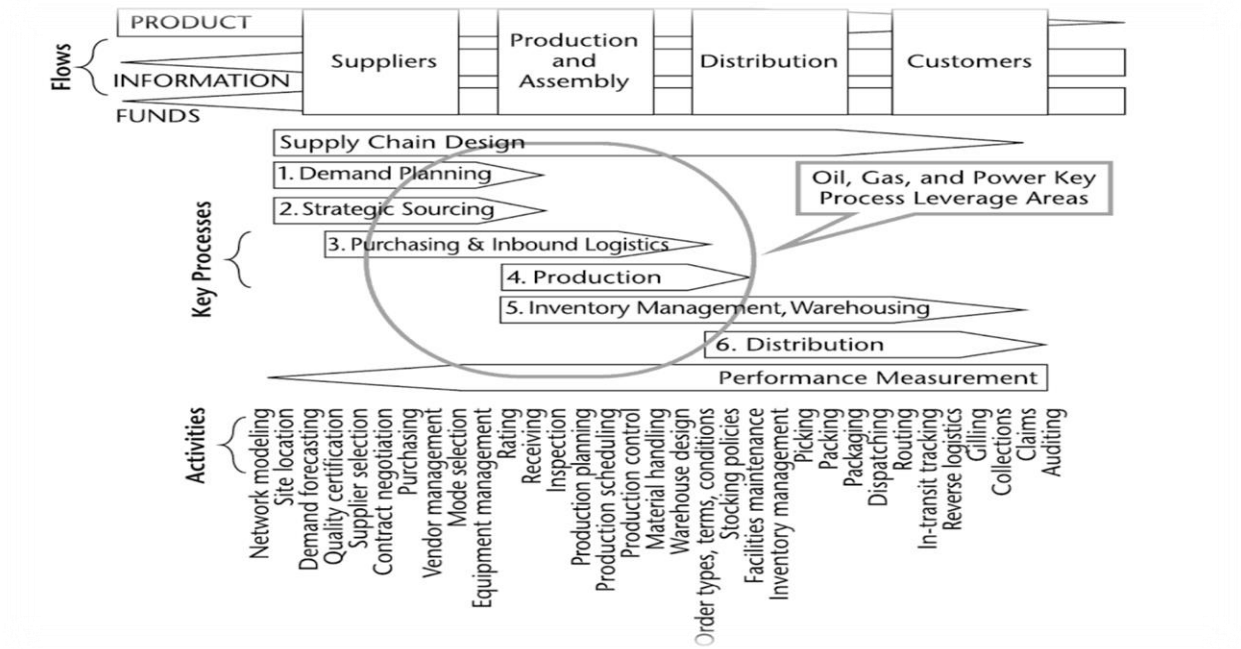


Figure 9: Generic Multi Industry SCM Process

Source: Optimal Supply Chain Management in Oil, Gas, And Power Generation- David Jacoby

Among these the circled components are key leverage areas for power sector. So utilizing these we can optimize the cost and efficiency. It includes inventory management, purchasing, production and strategic sourcing.

CHAPTER FIVE

SCM IN POWER SECTOR OF BANGLADESH & AROUND THE WORLD

Power sector of Bangladesh is about to face a radical change and it has to adapt new methodologies to keep up with the modern world. Costs of fossil fuel are soaring which in turn is increasing the power generation cost. Both public and private power plants of Bangladesh is going to face the previously mentioned challenges. So wise step would be to embrace the future and shave off traditional ways and pave way to a more effective infrastructure. SCM tools can have significant impact in this matter. This chapter will shed a light on how it can be fruitful in our country and also justify that with citations of the same from around the world.

Scopes & Prospects in Bangladesh

- Application of Utilities Supply Chain Management.
- Reducing system losses due to improper management.
- Increase cost effectiveness of power generation.
- Integrating value added model for the supply chain.
- Modernizing the aptisupply chain of BPDB.
- Reduction in per unit generation.
- Establishing an organized and methodical supply chain management system.

Supply Chain Strategy: Perspective BD Power Sector

There are chiefly four supply chain strategies and most appropriate one depends on the industry and line of business. But two generic supply chain strategies are most relatable and applicable for any power sector-

1. Rationalization: It is the aptitude in managing operating expense through SCM to achieve cost leadership and more profitability than competitors. Rationalization focuses on operating expense management rather than asset management, in particular for corporations that are driven by quarterly earnings. Rationalization includes supply chain processes such as SKU, Kaizen, value engineering and procurement functions like sourcing, production and facilities management.
2. Synchronization: It refers to the excellence in reaching reliable and flawless supply chain executions meaning to successfully utilize right product at right place at a right time. This

renders one to produce same volume of output with less fixed assets or production capacity and working capital or inventory. Synchronization includes processes such as inventory management, maintenance, routing and scheduling, demand planning, risk management etc. Six-sigma, design for assembly, standardization, collaborative fore casting etc. also fall under this segment.

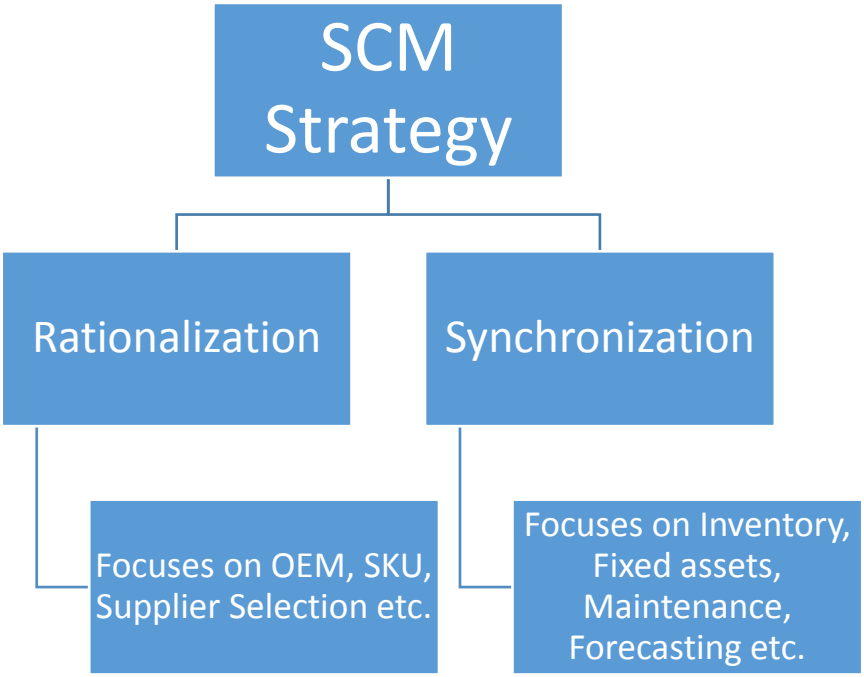


Figure 10: SCM Strategies

These two prominent stages are again leverage the following four common cost drivers-

- **Standardization:** Reduces number of items, parts etc. in service to maximize repetition within manufacturing and aftermarket.
- **Economies of Scale:** Cuts off costs due to volume purchase and amortized fixed costs across greater output.
- **Competitive Negotiations:** Bidding reduces prices as suppliers reduce their margin to win the order
- **Learning Curve Effect:** Productivity gains from product process and improvement over time.

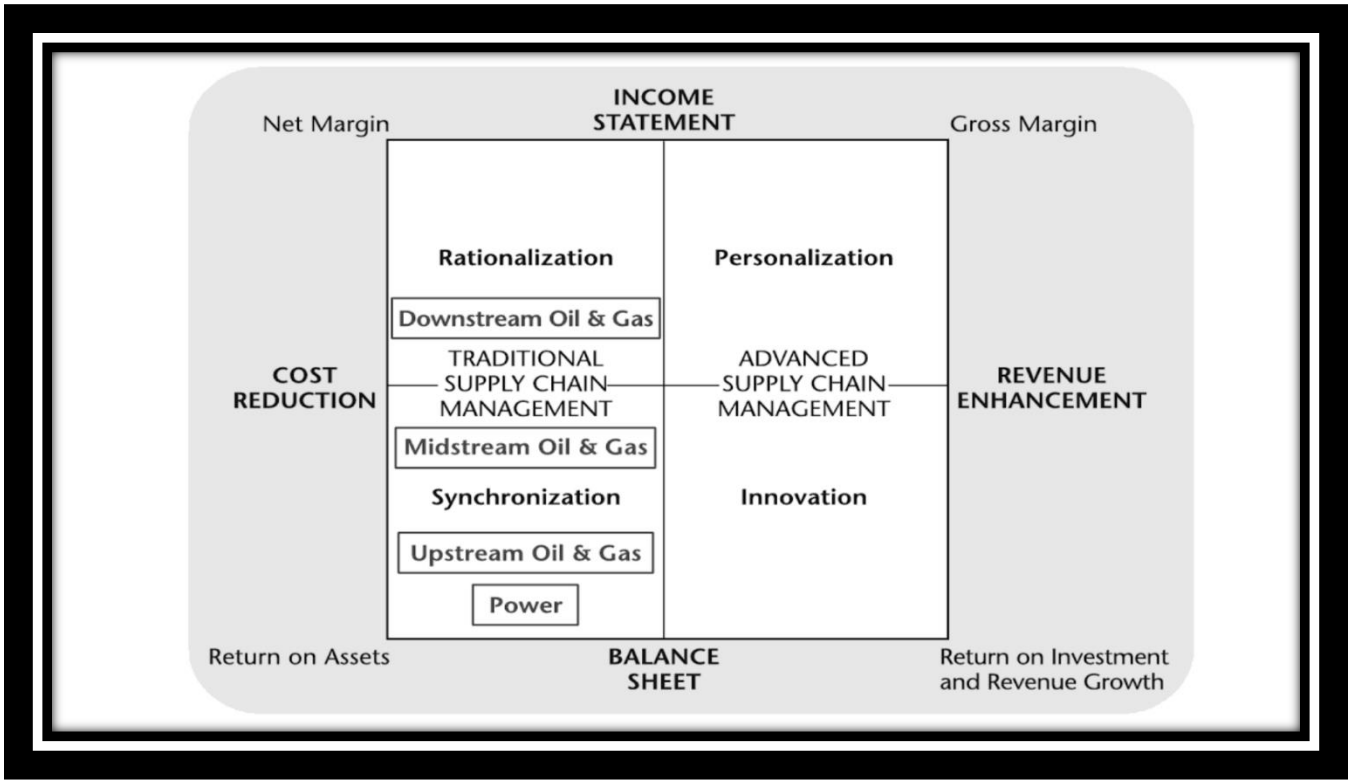


Figure 11: SCM Strategy Positioning

Source: Optimal Supply Chain Management in Oil, Gas, And Power Generation- David Jacoby

Applying Internal Realignment

One problem encountered by the procurement department is a tactical one rather than strategic. The traditional approach of having a dedicated supply chain for each business impedes improvement. These isolated chains are capable of acting strategically but unable to fully capture savings and efficiencies available through more centralized options. One way to mitigate this is to better align supply chains within a centralized directive.

In context of Diesel based power plants of our country if there is a centralized chain then all work will be a lot faster. As we observed it takes 2 days to get the HFO released from source and then another 1 day to transport to Hathazari. The reason behind this bureaucratic nightmare is the absence of centrally aligned procurement.

Thus using the internal realignment can benefit those plants and reduce cost and processing time.

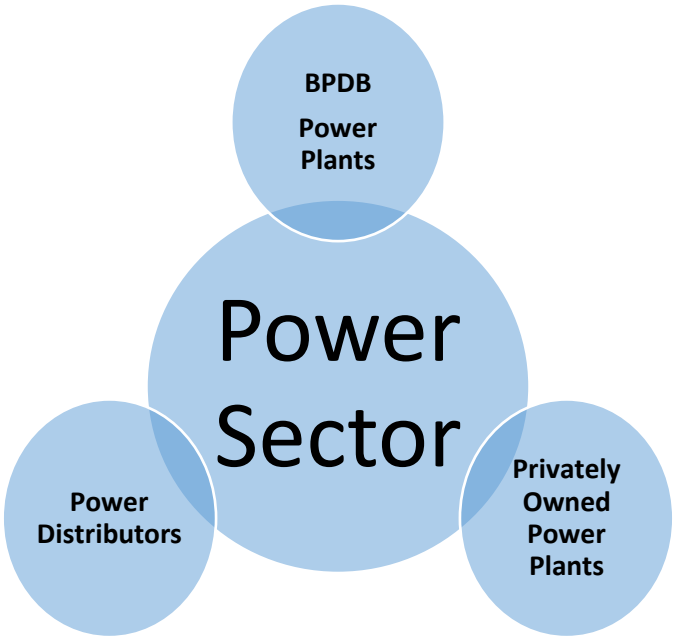


Figure 12: Alignment of Bangladeshi Power Generators

Applying Inventory Optimization

Though "just-in-time" sourcing has become the standard in many industries, the power sector has lagged well behind this trend, in part because—especially in regulated markets—a utility's focus is keeping the lights on and being able to respond rapidly to emergencies. While a bloated inventory full of stranded assets (spare components that the utility no longer has a need for) may not look good on the balance sheet, it rarely interferes with those priorities. Even in deregulated markets, poorly managed inventories don't necessarily prevent a plant from competing effectively. But over the long term, inventory problems can represent significant drains on revenue. Utilities and generators also have challenges not faced by other sectors. Critical replacement parts, some of which can be extremely expensive, must be kept on hand in case of emergencies even though they may never be needed. Utilities that operate in more than one state may be required to maintain duplicate inventories in order to meet requirements of separate state oversight. The problem can be compounded if the utility has merged with or been acquired by another company. Worse, the utility often may not have a clear picture of how much duplication exists or how much money is tied up in stranded assets. Implementing advanced supply chain management processes can help address these problems. Just as category management, improved data, and better communication

can streamline procurement, better information, segmentation, and tracking of inventory can assist a utility in identifying and clearing unneeded stores. Some utilities have made inventory management a separate director-level responsibility apart from other supply chain issues.

Optimized SCM in Coal Based Plants

Coal driven power plants probably face the biggest threats in terms of environmental pollution. Applying proper supply chain management system can also help minimize that. Using LCA (Life cycle assesment) study we can achieve that life cycle inventory and life cycle assessment of electricity coal can be established in three difference stages: coal mining, coal transportation, and coal burning. The electricity coal supply chain involves the coal mining process, coal transportation process and coal burning process.

The overall objectives of the LCA study are to:

• Demonstrate the usefulness of the LCA method in measuring the environmental impacts of a defined electricity coal supply chain system.

• Provide an overall understanding of an electricity coal supply chain and the associated with environmental burden involved in the main processes of the supply chain.

• Seek quantitatively the most effective way to reduce the environmental burden of waste gas emissions.

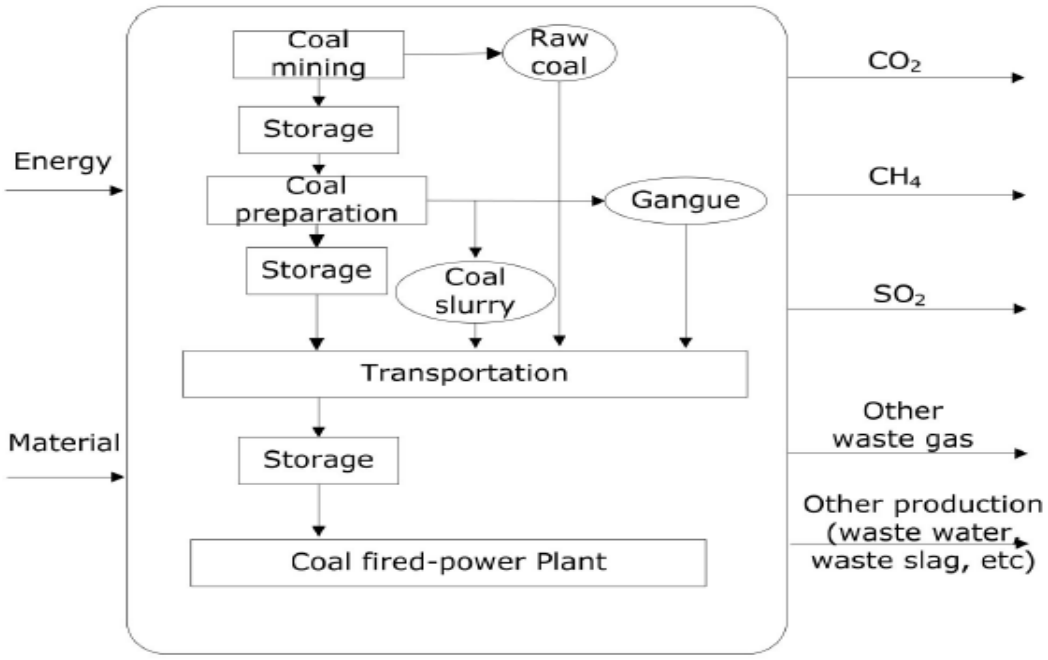


Figure 13: System Boundary of Coal Based Power Plants

Source: An LCA Study of an Electricity Coal Supply Chain

The model represents a “Mining to Products (MTP)” system as distinct from a “Cradle to Grave” system. This means that coal’s end of life (recycling) is not included in the study.

1. **Coal Mining Process:** In the coal mining process, a lot of waste gases will be released. For example, greenhouse gases like CO2 and CH4 will be released during the coal mining process, and gases like CO2, SO2, CO and H2S will be spontaneously released from coal gangues.

2. **Coal Transportation Process:** The atmospheric environmental problems arising in the coal transportation process are mainly caused by the burning of transport fuels, spontaneous combustion of coal in the process of transportation and coal dust pollution near the transport route.

3. **Coal Burning Process:** The coal-fired power plants in coal burning process often burn large quantities of low grade coal with high sulfur and high ash, even coal gangues, and are adjudged as the greatest sources of waste gases.

Characterization: In this step, the LCI data are sorted into ‘‘classes’’ or environmental impact categories according to the effect they have on the environment.

Global Warming Potential (GWP): It is derived by summing the emissions of the GHG multiplied by their respective GWP factors. The gases that contribute to Global Warming Potential are mainly CO, CO2, CH4, and N2O.

Eutrophication Potential (EP): It is defined as the potential of nutrients to cause over-fertilization of water and soil which in turn can result in increased growth of biomass.

Photochemical Oxidants Creation Potential: Photochemical Oxidants Creation Potential (POCP) is related to the potential for VOCs and oxides of nitrogen to generate photochemical or summer smog. It is usually expressed relative to the POCP classification factor for ethylene.

Acidification Potential: Acidification Potential (AP) is based on the contributions of SO2, NOx, HCl, NH3 and HF to the potential acid deposition in the form of H+ (protons).

Ozone Depletion Potential (ODP): Indicates the potential for emissions of chlorofluorocarbon (CFC) compounds and other halogenated hydrocarbons to deplete the ozone layer.

Normalization: A normalization step is performed to provide the relative size of each environmental impact.
Each of the total characterized scores is benchmarked against the known total effect (usually based on the country's average) for their respective ''class''. Currently there are many life cycle impact assessment (LCIA) methods such as CML 2001, Eco-Indicator 95 (Goedkoop, Demmers & Collignon, 1995), Eco-Indicator 99 (Goedkoop & Spriensma, 2001) etc.

Final weighted scores: It is assumed that the relative importance of various impacts is the same. However, in fact, the relative importance of various impacts is different, which on the one hand depends on the characteristics of the environment itself, while on the other hand this reflects the current understanding of human society and its degree of concern. In the final stage, the normalized scores are multiplied by a weighting factor representing the relative importance of the total environmental impact.

CHAPTER SIX

SWOT ANALYSIS OF SCM APPLICATION

Strengths

1) Field visit gave us a first hand knowledge about the power plants.
2) Less costlier solution to the upcoming challenges to face.
3) Successful proven SCM tools have been used.

Weakness

1) Not applied in any power plants in Bangladesh.
2) Changing age old process might cause some temporary disturbance

Opportunities

1) Could be the biggest weapon in upcoming hurdles to overcome in power generation
2) Environmental safety can also be achieved by maintaining the supply chain rules.

Threats

1) Applying this might not be enough to overcome the upcoming power deficiency.
2) lack of trained people in SCM might hinders the proper application of the whole process.

CHAPTER SIX

CONCLUSION

With the amount of challenges to overcome in upcoming days, its hightime for the power generation authority of the country to take a step.This effort is an one step forward for solving these problem. Our approach was mainly from the managerial sector. It is a relatively new approach in power sector.

To have an concrete evidence of improvement after applying SCM to power plants, we need to apply it in a real working power plant. Since power plants have National security issues, its not flexible on changing it process without the permission from higher authority. But based on the success of applying SCM to power plants in other countries and also based on our research, BPDB should consider applying the proper SCM tools we mentioned in any power plant and compare it's efficiency with others.

BIBLIOGRAPGHY

- A Supply Chain Network Perspective for Electric Power Generation, Supply, Transmission, and Consumption

  Author: Anna Nagurney and Dmytro Matsypura
  Department of Finance and Operations Management
  Isenberg School of Management
  University of Massachusetts.

- Short-Term Supply Chain Management in Upstream Natural Gas Systems

  Author: Ajay Selot
  MASSACHUSETTS INSTITUTE OF TECHNOLOGY
  February 2009

- Application of Supply Chain Tools In Power Plant- A Case of Rayalaseema Thermal Power Plant

  Author: S. Shakeel Ahamed , Dr.G.Rangajanardhana , E. L. Nagesh

- Exploring supply chain opportunities in the UK utilities sector and the supporting role of eMarketplaces

  Author: *Alan Smart*
  Centre for Logistics and Supply Chain Management,
  Cranfield School of Management, Bedford, UK.

- Electric Energy Access in Bangladesh

  Author: Muhammad Taheruzzaman and Przemyslaw Janik*
  Brandenburg Technical University-Cottbus, 03046 Cottbus, Germany
  Faculty of Electrical Engineering, Wroclaw University of Science and Technology, Poland.

- An LCA Study of an Electricity Coal Supply Chain

  Author: Chao Wang, Dong Mu
  School of Economics and Management, Beijing Jiaotong University (China)

- http://www.opg.com/working-with-opg/suppliers/supply-chain/Pages/Supply%20Chain.aspx

  Date of access : 9th October, 2017

- https://link.springer.com/chapter/10.1007/978-3-642-35267-6_55The Future of Utility Supply Chain Management, Thomas W. Overton, JD
- A Supply Chain Network Perspective for Electric Power Generation, Supply, Transmission and Consumption- Anna Nagurney & Dmytro Matsypura
- Optimal Supply Chain Management in Oil, Gas, And Power Generation- David Jacoby
- Creating value through supply chain integration-Lee, Hau L, MLA
- Bangladesh Power Development Board
- Manager, CTG Power Station
- Manager, Karnaphuli Hydro Power Plant
- Manager, Shikalbaha Power Station
- Manager, Hathazari Peaking Power Plant
- Manager, Tongi Power Station
- Short Term Supply Chain Management in Upstream Natural Gas System by Ajay Selot, Massachusetts Institute of Technology (MIT)
- Application of Supply Chain Tools in Power Plant- A Case Study of Rayalassema Thermal Power Plant by S. Shakeel Ahamed, Department of Mechanical Engineering, University College of Engineering, Andhra Pradesh, India
- Modeling the U.S. Coal Supply Chain by Julia Philips, Colorado School of Mines
- Electric Power Supply Chain Management Addressing Climate Change, Xiao Hui Wang & Rong Gang Cong, Tianjin University, China