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Challenges of Planning with Large Share of Heavy Steel Industry Load in Power System of Bangladesh and Tentative Solutions

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ABSTRACT: *With a rising level of industrialization, Bangladesh has experienced a steady increase in the industrial index in the case of the steel industry over the past two decades. So, sometimes the necessity of installing a new steel industry becomes mandatory in context to fulfill the increased demand. As large steel mills can be potentially harsh loads on an electric power system, proper power system planning is necessary to effectively design a steel industry to cope up with all challenges of planning. In this paper, a new steel industry has been proposed where different challenges that can be faced and their tentative solutions through generation expansion planning, substation expansion planning, network expansion planning and reactive power planning are discussed.*
KEYWORDS: *Economics of planning, Load forecasting, generation expansion planning, substation expansion planning, network expansion planning, reactive power planning*

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I. INTRODUCTION

The steel industry in Bangladesh is an established and growing industry; the industry produces for the domestic market as well as exports abroad. Compared to 2012, the production capacity of Bangladesh's steel industry has more than tripled during the financial years 2014–15, and actual production is expected to double by 2022 [1].

The steel industry plays a fundamental role in not only driving economic growth but also other complementary industries such as transportation, energy, heavy engineering and construction. With an estimated market size of 300 Billion BDT, the steel industry in Bangladesh is currently experiencing an upsurge in demand. This growth is driven mostly by government spending on infrastructure projects and the government's ADP plans which account for 40% of steel consumption in Bangladesh.Bangladesh is one of Asia's strongest emerging steel markets and with a growing need for raw materials and manufacturing technologies As the global steel industry continues to transition to a new phase, the local sector has the prime opportunity to not only grow to satisfy the domestic demand but also a secure position in the emerging export markets of tomorrow.[2] The local manufactures believe the steel industry should continue to grow at 10% in the next few years, riding on government programs centering its vision 2021[3].

To satisfy this increased demand in different sectors, in the future there might be the necessity of installing a new steel industry.As steel mills represent heavy loads on turbine generators,many issues will be related to this industrial load planning.In this paper,to install a new steel industry which types of machines are required to install, their capacity,installation process,related cost,factors influencing cost are discussed. To estimate the capacity of the Substation for a new steel industry,power system planning issues need to be considered like load forecasting to estimate demand,then generation expansion planning (GEP), substation expansion planning(SEP),network expansion planning(NEP),reactive power planning(RPP).The decision needs to be taken for-where to allocate the elements of this planning,when to install them and what to select as element specifications. Considering the present and future conditions, the exact calculation of demand is necessary to avoid surplus and shortage.

The paper will cover as followings-

Section II shows the energy consumption overview of the steel industry in Bangladesh, section III assumed the economics of planning of new steel industry, section IV discusses the challenges of planning, section V shows the installed capacity for the proposed steel mill, section VI explains the tentative solutions for

challenges and in section V the conclusion will highlight how steel industry impacts on the power system of Bangladesh as heavy load industry.

II. ENERGY CONSUMPTION OVERVIEW OF STEEL INDUSTRY IN BANGLADESH

According to a governmental study, the steel industry in the country uses around 2.25% of the total primary energy consumed. Along with the projected growth of Bangladesh as an industrial economy, the steel industry itself is expected to grow by more than 15% as this is an energy-intensive industry. [2] Most of the re-rollers are adopting backward integration process in order to produce quality and cost-effective products. Large players such as Abul Khair (AKS) & BSRM are reported to have already commissioned high capacity induction & electric arc furnaces which would expand crude steel (billet) production significantly. As a result of significant investment by the giant steel millers in steel melting plants to produce billets, Bangladesh is now capable of supplying 90% of the required local demand for billets. However, the country still needs to import billet because most of the billet millers mostly serve as thebackward for their own re -rolling mills [3]. This represents the urgency to increase the capacities of our steel industries.

Accordingly, based on the above discussion a growth rate of 10% which is slightly lower than the expected growth rate of the country's GDP during the GTP period (2011 – 2015) is used. Based on the above assumption and using the estimated present unsatisfied demand as a base the projected unsatisfied demand for steel profiles is shown in the table 1 [4]-

TABLE: 1 Projected Unsatisfied Demand For Steel Profiles

Year	Projected Demand (KW)
2013	66,958
2014	73,654
2015	81,019
2016	89,121
2017	98,033
2018	107,836
2019	118,620
2020	130,482
2021	143,530
2022	157,883
2023	173,671
2024	191,039
2025	210,142

III. ECONOMICS OF PLANNING FOR THE NEW STEEL INDUSTRY

For planning a new steel industry, economic analysis is the first priority. Different types of cost calculations are included for obtaining cost –benefit from the proposed steel plant. the total cost includes investment cost and operational cost. Let assume that, the total investment cost includes 11.3% is for plant and machinery, 23.5% for working capital,35% for building and civil works and the rest 30.2% is to be expended for land cost, vehicle, office equipment, and other prep-production expenses Considering the production process involved and time to take to master the operation, the plant will start to produce at 75% of its installed capacity. In the second year, it will increase to 85% and in the third year and then after it will attain full capacity operation. The planned capacity will be achieved in the third year of the establishment year of the factory. After completion of a year of project time, the project will be realized and will continue to work with this capacity for the coming 10 years. The location of the plant is determined by the proximity of raw materials, availability of infrastructure, availability of skilled manpower, and distance to the potential market outlet.

IV. CHALLENGES OF PLANNING IN STEEL INDUSTRY

Some of the major challenges that are faced by a new steel industry while planning to install are as follows:

A. Capital

The steel industry requires large capital investment which a developing country like Bangladesh cannot afford. We have no iron core in our country so it's our major drawback to import raw materials from other country. As the steel market price is variable, sourcing of raw material is important. A shortage or price hike of raw materials will affect the company's operation.

B. Shortage of power and gas

Steel industries require huge and uninterrupted power supply. Load shedding has caused the steel production capacity to reduce by 20% in last 20 years found in energy crisis analysis**.** Any unfavorable changes in power-related regulations may affect the company's business. Companies also require for heating billets and

accordingly shortage of gas supply will affect the operation of the company. As electricity tariff has increased in recent years, the production cost has risen immensely. Sometimes steel mills use an alternative source of energy like own installed generator that also increases their production cost.

C. Lack of technology

The oil crisis, steep hike in energy costs and escalation of costs of other inputs, reduced the margin of profit of the steel plants resulted in a lower level of investments in technological development. That also increasesthe production cost of installing new steel plant.

D. Interest rate risk

Interest rate is the risk that the company faces due to unfavorable movement in the interest rates. Changes in the Government's monetary policy, along with increased demand for loans/investments trend to increase the interest rate. Such rises in interest rates mostly affect companies having floating rate loans or companies investing in debt securities.

E. Operational risk

Non-availability of material /equipment may affect the smooth operational activities of the company. On the other hand, the equipment may face operational and mechanical failure due to natural disasters, terrorist's attacks, lack of supervision & negligence, leading to severe accidents & losses.

F. Changes in regulations

Any abrupt changes of the policies (such as: Custom Act, Income tax, Value added tax, and other related) of the policies made by the regulatory authorities may adversely affect the business of the company.

G. Heavy demand

Even at low per capita consumption rate, demand for steel isincreasing with each passing day and large quantities of steel are to be imported for meeting the demands. Production has to be increased to save precious foreign exchange. Moreover this induces demand supply gap. These problems include lack of power, obsolete machinery, low capacity utilization, lack of machinery maintenance, labor unrest and militancy and a lack of working capital.

V. INSTALLED CAPACITY FOR PROPOSED MILL

The main energy sources for energy in the steel industry in Bangladesh are electricity, natural gas and high speed diesel (HSD). Electricity is consumed by induction furnaces and gas is predominantly used in re-rolling mills. Some manufacturers use gas-based self-generation, which is around 30% cheaper than grid-connected electricity, while HSD is mainly used to run a backup of the utility services. In general. energy in the steel industry is mostly used in the forms of electricity as a common power source for machinery, cooling and temperature control systems, lighting, office equipment etc. oil as a fuel for boilers which generate steam, liquefied petroleum gas, coal and city gas[1].The installed capacity for the proposed steel industry is shown the following table 2-

TABLE 2 : Installed Capacity For The Proposed Steel Industry

Equipment Type	No. of Machines	Installed Power (KW) (For unit machines)	Installed Power (KW) (For Total)
Furnace Body	1	500	500
Hydraulic oil pump	2	37	74
Rectifier Transformer	1	500	500
Rectifier Circuit (inverter)	1	1400	1400
DC reactor	3	4	12
Capacitor Bank	5	3	15
Changeover switch	12	2	24
Charging Car	2	5.5	11
Wire feeding motor	10	3	30
LRF transformer	3	30	90
APC motor	2	600	1200
Thyristor	10	5	50
Rolls Royce gas engine	1	3000	3000
Perkins diesel engine	1	1200	1200
Coil cooling motor	2	55	110
Cabinet cooling Motor	4	50	200

Lining Transformer	3	30	90
Rolling Motor Drive	1	1000	1000
Ac motor drive	1	300	300
Crane motor	8	50	400
Total			10,206

According to the table 2, the total load for the proposed industry is approximately 10.5 MW (a bit higher than 10.206 MW). It is projected considering the future demand of local and international consumers. There are several planning steps that need to be considered for efficient and proper management of demand and supply in the long run.

VI. TENTATIVE SOLUTIONS

Proper step by step planning in different stages can be helpful to overcome the above challenges. In this paper, it is assumed that the installed capacity of the proposed steel industry will be approximately 10.5MW**.** For solving the challenges of this type of heavy load industry and installing the proposed steel industry some tentative solutions in each step of planning are discussed below-

A. Load forecasting

Load forecasting can solve the challenges due to capital, operational risk and demand-supply gap. Long-term load forecasting (LTLF) will be feasible for this planning as we opt to predict the system behavior for a longer period. Here Trend extrapolation (trend analysis) method is used where we have used past load information of steel industry, growth of population, domestic and international demand to forecast the future demand from our installed steel plant. Analysis is conducted for last 10 years of period. This will help to take a decision whether the proposed steel mill will be able to meetthe future demand or we need to expand the existing one. In the next 10 years, the load is predicted to be 22MW.

B. Generation Expansion Planning (GEP)

In long term planning issues, the forecasted load is specified then GEP will help to overcome the shortage of electricity demand.New modernized equipment should be installed to reduce the demand-supply gap. New generator may need to be installed to meet the extra electricity demand.

Here we consider that our proposed industry has total estimated demand of 12 MW with 10% reserve margin. To meet the demand two different types of plants are initially established, one Gas turbine power plant (with natural gas) of 10MW and one thermal power plant (with oil fuel) of 5 MW. By load forecasting, it is assumed that the future demand will be 22 MW and the reserve capacity is 10% of the peak load. Three candidate plants are considered 1 diesel plant, 1 gas turbine power plant, 1 thermal power plant for future demand.

Figure 1 shows our proposed design where two buses have been considered. The gas turbine plant in bus 1, thermal plant in bus 2 are installed and the load are connected to bus 3 .By using the Power World Simulator tool, it is shown below that our proposed system is feasible as there is no thermal limit violation as line flow constraints are checked.

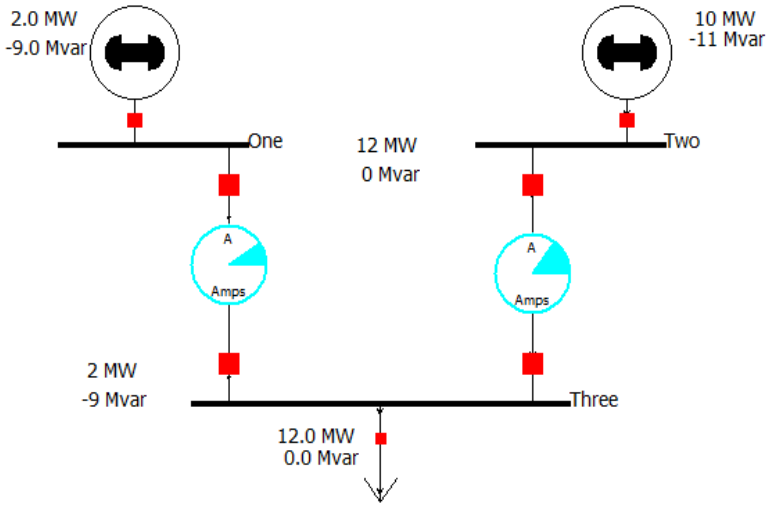

Fig. 1. Load Flow of proposed steel industry

In figure 2, three candidate plants- 1 diesel plant of 4MW in bus 3, 1 gas turbine plant of 10MW and 1 thermal plant of 8 MW in bus 2 are showed-

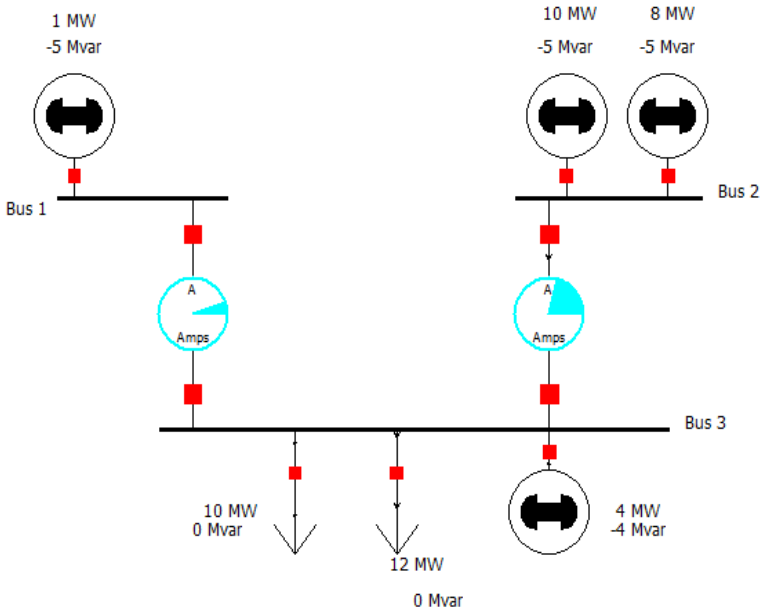

Fig.2. Load Flow of predicted future load after load forecasting

C. Substation Expansion Planning (SEP)

SEP can solve the problem of shortage of power.A substation consists of high voltage electrical equipment such as transformers, switch gear, and circuit breakers. The purpose of a substation is to 'step down' high voltage electricity from the transmission system to lower voltage electricity so it can be easily supplied to homes and businesses in the area through lower-voltage distribution lines. Whenever a new industry is installed in an area, electricity demand increases. When the electrical infrastructure in an area is at full capacity, a substation is required to continue to provide reliable electricity. A large steel mill required individual substation to fulfill its electricity requirement to prevent the crisis. Considering all types of constraints of HV substations, upward and downward grid, suitable cost effective plan is considered for expansion planning. This solution is obtained by applying Binary Integer Linear Programming (BILP) method.

D. Network Expansion Planning (NEP)

NEP can solve the problem of operational risk by transmitting power efficiently and reliable manner from generation resources to the load machineries. Proper specification of cables and also transmission lines will solve the power failure problem and low capacity utilization. DCLF is done for assumed normal condition and (N-1) contingency conditions. If load increase by 50% in last 10 years (assumed),there may be a possibility that transmission lines are violating line limits. There are different solution methodologies. In this paper, we propose to use the decrease method (using a combination of backward and decrease approach) to find whether the installed generation resources hamper the network capacity and cause line overloading.

E. Reactive Power Planning(RPP)

The key of reactive power planning (RPP) includes proper optimal allocation of reactive power sources considering proper location and size. For maintaining the voltage profile and voltage stability in the steel industry system, RPP is mandatory. Recent research works have presented some rigorous optimization-based methods in RPP. [5]

For RPP the following assumptions are considered:

- The system is balanced.
- The active and reactive power represent fundamental frequency powers, and additional powers at harmonic frequencies are negligible.
- The size of the VAR source is treated as a continuous variable; however, it is in fact discrete [5].

Optimal allocation of VAR sources such as Static VAR Components (SVC), Static Compensators (STATCOM) and Capacitor Banks, are the critical components in reactive power planning (RPP) Though Dynamic VAR sources (SVCs, STATCOMs, Synchronous generators etc) have fast response time while static VAR sources (capacitors, reactors) have relatively slow response time [6].

VII. CONCLUSIONS

This paper aims to the increased future demand in the steel industry and a model of the proposed steel industry is proposed here. The major challenges faced in the establishment of the industry and the tentative solutions with mitigation techniques in different stages are discussed. This solution methodologies will help to improve energy management and energy efficiency among large steel mills in Bangladesh. The obstacles while planning for static reactive resources in the establishment of the steel industry may affect voltage profile and voltage stability and for this reason after generation expansion planning, substation expansion planning, network expansion planning optimization technique for reactive power planning is taken into consideration.

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