Power System Planning Assignment 1
Sahiwal, Mohmand and Diamer Power Plants.

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2018-MS-EE-4

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Abstract: This paper summarizes the technical, administrative and socio-political challenges faced in the construction of Sahiwal Coal Power Plant; and illustrates how the Chinese Companies addressed those hindrances to make the mega project a success within almost two years. The latter part discusses the construction of Diamer and Mohmand dams. These dams are very valuable since they will provide cheap, clean energy and act as a valuable source of water storage to avert the water shortage. It also sheds light on the financial and administrative obstacles faced by the government in making these dams; and the setbacks which have delayed their construction.

***Index Terms*—Supercritical Technology, Belt and Road Initiative, Flue Gas Desulphurization System, Spillway.**

I. Introduction

A coal thermal power plant operates by converting the chemical energy stored in coal to mechanical energy of high pressure steam in a boiler. The steam is used to spin a turbine to generate electrical energy by electromagnetic induction. The Sahiwal Coal Power Plant meets all the world standards as one of the most environmentally friendly thermal power plant [1]. It has emission levels well below the World Bank standards. It was built in just 22 months and has a record efficiency as well [2].

A hydroelectric power plant works by converting the gravitational potential energy of falling water to mechanical energy of a turbine. The mechanical energy of spinning turbine is converted to electrical energy by electromagnetic induction. The Diamer-Bhasha dam is going to be the biggest hydropower project of Pakistan which will break the record of Tarbela dam. Diamer-Bhasha and Mohmand dams have enough installed capacity to end the present energy deficit of Pakistan.

II. Sahiwal Coal Power Plant

A. Introduction

Sahiwal Coal Power Plant consists of two 660 MW thermal power plants built near Qadirabad, Sahiwal under the China Pakistan Economic Corridor's "Belt and Road" Initiative [1]. The project was built on the basis of Build, Operate and Transfer, whereby the Chinese Huaneng Shandong Power Generation Co. and Shandong Ruyi Technology Group Co. would build and operate the power plant; and sell the generated electricity to the government of Pakistan [4] at a tariff of 8.3601 US Cents/ KWh [2]. China has the most advanced Supercritical technology of thermal power generation [5] hence the project is recognized as a great engineering feat. The $1.8 billion funding was primarily provided by The Industrial and Commercial Bank of China, National Electric Power Regulatory Authority issued the generation license, Punjab Power Development Board approved feasibility study, the Load Flow Analysis and simulations were done by National Transmission and Despatch Company, and The Environmental Impact Analysis Report was prepared by Environment Protection Department Punjab [2].

B. Construction

The project was completed it 2017 and took about two years to construct. The power plant was built on 240 hectares government owned and 450 hectares privately owned agricultural land and has a designed service life of 50 years [2]. 3000 workers including 1000 Chinese worked on the project [4]. The main components [2] of the Sahiwal coal power plant include:

1) Pulverized Coal low NOx Boiler with Superheater and Reheater for steam temperature regulation at 566ºC.
2) 660MW Steam turbine with rated speed 3000 r/min.
3) Statistic excitation 660MW, 22kV Generator with rated speed 3000 r/min and rated power factor 0.85, directly coupled to turbine shaft.

4) Single phase, oil immersed, double winding 22kV/ 500kV 840MVA Step Up Main Transformer, with forced-directed oil and forced air cooling.

5) Two 0.5 km long, quad-bundled Drake Conductor 500kV DC Transmission Lines.

6) 500kV Switchgear.

7) Single phase grounding transformer.

8) Deaerator bay to remove oxygen and other dissolved gases from water.

9) Ash yard for dry pneumatic ash/ mechanical slag piling with anti-seepage geomembrane, rollers and compactors.

10) Flue gas desulphurization system and SO_2 absorption tower.

11) 180m high chimneys and cooling towers.

12) Green Belt of 30000 plants.

13) Water Treatment Plant for waste water reuse.

14) Dust suppression net.

15) Air Quality Monitoring System.

16) Noise Dampers to reduce vibration.

17) Railway line from Port Qasim, Karachi to Yusuf Wala Railway Station, Sahiwal.

18) Pile Foundation treatment for protection from earthquakes.

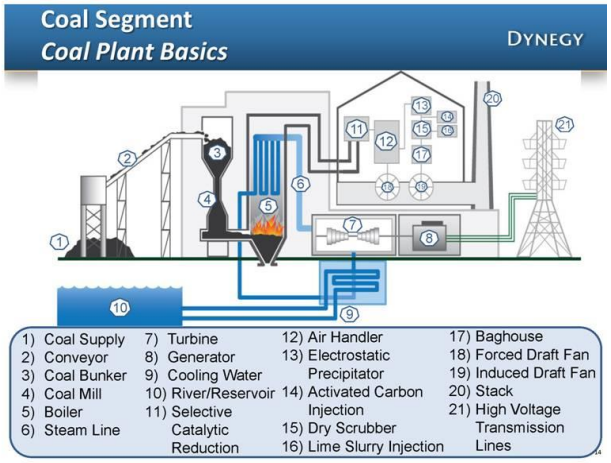

Fig. 1. Coal Power Plant [25]

C. Operation

The Sahiwal Power Plant uses Supercritical technology, whereby steam operation conditions (242 bars) are above the critical pressure of water (221.255 bars). Above this critical pressure, the density of water and steam is the same and leads to a Gross power plant efficiency of 42.11% [2]. The Standard Rate of coal consumption for power generation is 291.65g/ KWh [2]. The Sahiwal Coal Power Plant produces 8976GWh annually [1] with a 46592 tonnes annual coal consumption [2]. Thar Coal was found unsuitable for the project due to excessive sulfur and lime [4] so Coal is imported from Indonesia and South Africa to Port Qasim, Karachi. A new 1100km railway line was built to link Yusuf Wala Station, Sahiwal to Port Qasim, Karachi [2]. China's Jinan Railway Company provided 800 hopper wagons and General Electric, United States supplied 55 diesel electric locomotives for coal transport [6]. Five freight trains transport coal daily; contributing to annual Pakistan railway earning of Rs. 6 billion [6]. The 20 million m^3 annual water need is met by Lower Bari Doab Canal [2]. The Main Plant Control uses Decentralized control system, whereas the Auxiliary Plant uses Programmable Logic Controller. The Limestone Gypsum Wet Flue Gas Desulphurization technology is 80% efficient [2]. The SO_2 emissions are kept below 1700mg/ Nm^3 and dust emissions are kept below 50mg/ Nm^3 [2]. According to International Energy Agency Report the power plant is not injurious to health [4]. A green belt of 30000 saplings was planted to improve the ecosystem of the area [5]. 350 workers are required to operate the power plant [2]. Cement, sand, crush, wood, building materials and furniture was bought from local market of Sahiwal. The project boosted foreign investments, provided employment opportunities to local workers and started adding electricity to national grid by 2016 [3].

III. Diamer Bhasha Dam

A. Introduction

The Diamer-Bhasha Dam will be located on Indus River, 315km upstream of Tarbela Dam and 165 km downstream of Gilgit [10]. The construction began in 2011 and is expected to be completed by 2023 [7]. It will have an installed capacity of 4500MW and an average annual generation of 16.5 TWh [10]. The mean annual discharge of Indus River at the site is 62 billion m^3. The dam will cover an area of 110km^2 and the reservoir will have a live water storage of 7.9 billion m^3 [10]. With a maximum height of 270m; it is going to be the World's highest roller compacted concrete (RCC) dam [10]. Although the project's ground breaking has been done five times in 15 years, the project is facing major hindrances to its progress [15]. The estimated cost of the project is a staggering $14 billion [11], which neither Asian Development Bank nor World Bank would finance [12] [13] because the region is considered a disputed territory and a No Objection Certificate was required from the neighboring India [15]. Pakistan has withdrawn its request to include Diamer-Bhasha Dam in the China Pakistan Economic Corridor (CPEC) framework because Chinese wanted ownership

of the project by pledging another operational dam [15].

B. Planning

Prime Minister Shahid Khaqan Abbasi approved financing of dam from country's own resources in 2017 when he devised that the federal Government would provide Rs.30 billion per annum to complete the project in 10-12 years [14]. In 2018, the Chief Justice of Supreme Court directed the Government to build Diamer-Bhasha dam and Mohmand dam on an emergency basis to prevent water shortage [16]; and a Diamer-Bhasha, Mohmand Dam Fund was established for this purpose [17]. Budget was allocated for acquisition of land, building nine model villages for resettlement of 22000 affected people, pay and allowances of administrative arrangements, infrastructure etc. The scheme is split into Dam storage and power generation; whereby the construction of dam will get higher priority [15]. The main features of the project [15] include:

1) Diversion system consisting of two diversion tunnels, Upstream and Downstream cofferdams and a diversion canal.
2) Main spillway with 9 gates of dimensions: 16.5m X 15 m.
3) Reservoir with gross storage capacity of 9 billion m^3 and live storage capacity of 7.9 billion m^3.
4) 8 Intermediate level outlets and 4 low level outlets.
5) Two Power houses installed at toe of dam with eight units of 560MW each.

No irrigation canals can be taken out of the dam because of the hilly terrain [9]. Nonetheless, the project will provide employment opportunities for local workers, provide cheap clean energy supply and act as a valuable source of water storage for agricultural purposes, flood control and for resolving water shortage.

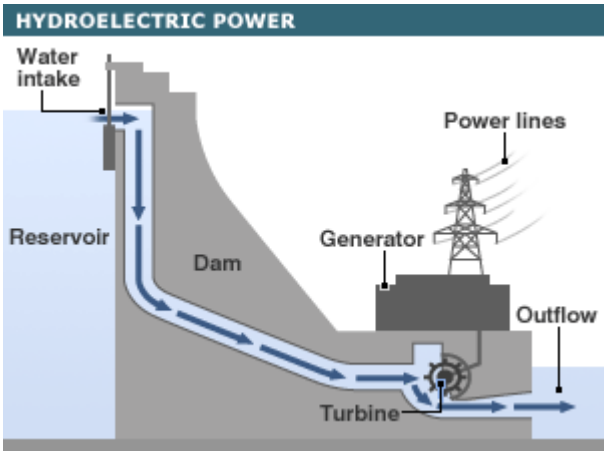

Fig. 2. Hydroelectric Power Plant [26]

IV. Mohmand Dam

A. Introduction

The Mohmand Dam is a concrete-filled rock-faced dam project located on the Swat River, 37 km north of Peshawar and 5 km upstream from the Munda Headworks in Mohmand District, Khyber Pakhtunkhwa [23]. With a total area of 69 km^2, a live storage capacity of 0.8 billion m^3 and a height of 213m, it has an installed capacity of 740MW and will generate 2407GWh annually [18]. It can store enough water to irrigate 15000 acres of land [19].

B. Planning

The mega power project has a total estimated cost of $1.4 billion [18]. The feasibility study was reviewed and submitted by AMZO American Firm to Private Power Infrastructure Board in 2006 [18]. The detailed engineering design and construction was assigned to Water and Power Development Authority [18]. Nine consulting firms sent Expression of Interest for the project. Snowy Mountains Engineering Corporation Australia, Nippon Koe Japan and NESPAK, ACE, AJC and BAK were finalized as the detailed engineering consultancy firms in 2011 by The Central Development Working Party [18]. French Development Agency issued the No Objection Certificate [18]. The detailed engineering designs and tender documents were expected to be submitted in 2014, but the work was suspended when WAPDA stopped payments to consultants in 2013 due to delay of revised feasibility report [18]. Although, France has donated Euro 61 million for the project [23], collecting funds for the project turned out to be a very daunting task and work remained suspended for many years [24]. Finally, in 2018, the Chief Justice of Supreme Court directed the Government to build Diamer-Bhasha dam and Mohmand dam on a priority basis to prevent water shortage [16]; and a Diamer-Bhasha, Mohmand Dam Fund was established for this purpose [17].

V. Conclusion

The primary reason for the overwhelming energy crisis facing our country is the flawed energy policy of spending funds on expensive thermal power plants as opposed to hydroelectric power plants. Although the capital costs of constructing a coal power plant are low, the operating costs are very high. Also, the plant efficiency is very low. The fossil fuels are scarce and expensive, a lot of maintenance costs are incurred and the plant produces harmful emissions which can be damaging for the environment. On the other hand, a hydroelectric power plant requires a high capital cost but has very little operating costs. Plus, it has a very high efficiency of 80 - 90 %. The hydroelectric power plant produces cheap, clean energy without

harming the environment. It can be used for water storage, irrigation and flood control as well.

A major problem that reduces the efficiency of hydroelectric power plants is sedimentation in reservoirs which reduces the storage capacity. Tarbela, Mangla and Chashma reservoirs have already lost about 6.2 billion m^3 due to sedimentation [10]. Even though our country desperately needs more sources of renewable energy generation, no new dams have been built in the last 40 years [16]. The main reasons for the developmental setbacks are lack of funding and inability to service the burdensome external debts. Diamer-Bhasha and Mohmand dams seem like a ray of hope to revive the industry of Pakistan, generate cheap electricity to lower existing tariff, end load shedding, stimulate socio-economic development and to generate employment. The entire nation is joining hands and contributing to the Diamer-Bhasha, Mohmand Dam Fund [17].

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