# INDIAN MARKET POTENTIAL FOR CHP AND FUTURE STRATEGIES

**Pramod B. Lanjewar**
Lecturer
Department of Mechanical Engineering
St. Vincent Pallotti College of Engineering & Technology
Gavsi Manapur, Wardha Road, Nagpur 441108 (M.S.)
Phone: 07103 261711, 261712
Fax: 07103 261632
Email: pbl7478@yahoo.co.in

## 1. Introduction

Power sector in India has grown at a phenomenal rate during the last four decades to meet the rapidly growing demand for electricity as a commercial fuel. Electric utilities have in the past adopted the conventional approach of adding new generating capacities to meet the demand. However, financial constraints aggravated by sub-optimal operations of the existing facilities of power generation and supply have resulted in both energy and peak shortages since midseventies. In this context, CHP presents an important option to meet the demand for electricity and heat in a most cost-effective manner. Electricity generated can be used to meet the internal electric requirements and thus reduce the demand for utility power and additionally the surplus, if any, could be sold to the utilities. CHP thus provides an alternative to the conventional utility power and reduces the overall emissions from the power sector.

Despite the fact that CHP is currently being practiced in Indian industry, there are no efforts to optimize the steam and power requirements. As a consequence the CHP systems installed meet steam requirements completely while generally a part of total power requirements are met. Also, no efforts are made towards installing CHP systems that could generate surplus electricity. Many industries are compelled to continue with non-optimum systems for various reasons such as company investment criteria, availability of equipment, incremental costs and reliability and above all, government regulations.

## 2. Benefit of CHP system

CHP is an efficient production of two forms of useful energy from the same fuel resource, using the exhaust energy from one production system as the input for the other. Ordinarily the primary energy form is thermal (steam) and the secondary form is either electrical or mechanical. The electrical or mechanical energy can be used internally to run plant equipment, and the surplus electricity, if available, can be sold to the utilities. Such a system can reduce energy input to 10-30% of what is required by separate systems to produce the same outputs. Total system efficiency can approach 90%, a significant improvement over the 50-90% efficiency of many industrial boilers and 30-35% efficiency of electrical conversion when separate production is used. As a result, this simultaneous efficient production of two energy forms can significantly reduce total operating costs in many instances, even after paying for the increased capital costs.

The benefits of CHP listed below are derived from improved power cycle efficiency and an associated reduction in fuel consumption as compared to the conventional power plant utilizing fuel solely for generating electric energy.

1. High efficiency can be achieved by utilizing the same fuel to provide heat and electricity and thereby,
- reduce fuel consumption
- reduce fuel cost
- reduce electric utility bills
- provide economic competitive advantages through a maximized return on investment capital
- ensure efficient use of capital investment

2. The amount of useful energy produced can be increased through the recovery of otherwise wasted heat.

3. Energy conservation
- improve energy efficiency by implementing an energy conservation plan
- convert any existing standby power generator set to a continuous profit producer
- recover heat energy from cooling and exhaust systems to add profits to the operation
- minimize utility electricity demand
- utilize available energy for internal process applications and displace other less efficient sources.

4. A lesser effect on the environment because of efficient fuel use
- reduced air emissions (sulfur dioxide, nitrogen oxides, particulate)
- reduced thermal pollution

5. A reliable source of power and process steam or heat. This is particularly important in regions prone to frequent disruptions in electricity supply.

6. On-site electricity generation can eliminate losses (8-10%) in the transmission and distribution systems.

7. CHP plants can be placed in operation in 2 to 3 years compared to 5 to 6 years for conventional power plants.

3. Present status of CHP technologies available in India

A CHP system is an integration of the various components (energy conversion system, balance of-plant systems, heat source, heat pump, etc.) into a total system which provides the electrical and thermal requirements of a specified industrial process. CHP systems can be broadly categorized into two groups - topping cycle and bottoming cycle.

In topping cycle, the primary fuel is used to produce electricity and the thermal energy exhausted is used for process heating. In the bottoming cycle system, the primary fuel is used to produce high temperature thermal energy. The hot exhaust steam is subsequently used to produce electrical energy through waste heat boiler and turbine generator system. The specific components comprising a CHP plant will, however, depend upon the industry, the energy conversion system, and the strategy picked for sizing the energy conversion system.

A brief status report on the technology and availability of some of the components of a CHP system in India is given below:

3.1 Boilers

The major boiler manufacturers are BHEL, Thermax, Walchandnagar Industries, Texmaco, ISGEC, IBPL, Lipi, ACC - Babcock and others. Most of the major boiler manufacturers have collaborations with leading boiler manufacturers in the world, e.g., Combustion Engineering, Babcock and Wilcox, John Thompson, etc. Both conventional and fluidized bed combustion (FBC) boilers are being manufactured in India.

Convention boilers are available as packaged or field erected units in a wide range of capacities and with fuel capability ranging from oil, gas and coal to rice husk and bagasse. Typical examples of large size boilers supplied are 275 tph for coal fired boilers and 130 tph for oil/gasfired boilers. Packaged oil/gas fired boilers of 80 tph are also in use. The large 275 tph boilers (supplied to electric utilities) supply steam at a pressure of 96 kg/cm$^2$ at a temperature of 530$^0$ C. Boilers with steam pressures up to 110 kg/cm$^2$ at 465$^0$ C have also been supplied for industrial applications.

Fluidised bed combustion (FBC) boilers are also available in the country and BHEL,CetharVessels, Thermax, Kavery Engineering, Walchandnagar Industries, are among the major manufacturers of these boilers. FBC boilers have been manufactured in a wide range of capacities are being manufactured to fire a variety of fuels such as high sulphur and high ash coal, rice husk, rice straw and even low grade fuels such as coal washery rejects.

3.2 Steam turbines

There are three manufacturers of steam turbines in India. They are APE Belliss, Triveni Engineering Works and BHEL. APE Belliss and Triveni manufacture turbines in the lower rating range starting from a few hundred kilowatts to 5-6 MW. BHEL manufactures steam turbines in a wider range of capacities from 1 MW to 500 MW (for thermal power plants). These turbines are available in different configurations, i.e., simple back-pressure, condensing, extraction condensing and multiple extraction turbines.

In the lower range of capacity (up to 5 MW) steam turbines are being manufactured to operate at pressures of 30 to 45 kg/cm$^2$. Most of these turbines are supplied to the sugar industry, and these turbines conform to specifications as laid down by the National Federation of Cooperative Sugar Factories Limited. Manufacturers of these turbines claim to have the capability to manufacture turbines rated higher than 65 kg/cm$^2$ with maximum extraction at about 22 kg/cm$^2$ for the extraction steam turbines.

BHEL manufacturers steam turbines operating at pressures up to 100 kg/cm$^2$ and have the capacities to manufacture machines at higher pressures. Turbines with back-pressure of over 22 kg/cm$^2$ have been supplied. BHEL also offers multiple extraction steam turbines with extraction at pressures higher than 22 kg/cm$^2$.

Single-stage back-pressure turbines typically operate at an efficiency of 30-40% and for multistage back pressure turbines the efficiency is in the range of 40-50%. For condensing turbines, typical efficiencies are in the range of 60-70%.

3.3 Gas turbines

In India, gas turbines are available from BHEL, Triveni Engineering Works and DLF Energy Systems and Kirloskar oil engines. While BHEL and Triveni supply heavy-duty industrial gas turbines (typically in the range of 4.5 to 38 MW), DLF Energy Systems supply aero-derivative gas turbines (1-5 MW range). BHEL is the only manufacturer of gas turbines in the country and these machines are made in collaboration with General Electric. Triveni and DLF Energy Systems supply Ruston and Allison-GM machines respectively. Typically, gas turbines operate at an efficiency of 22-26% (typical Indian operating conditions) in the lower ratings up to 5 MW.

3.4 Diesel engines

There are various manufacturers of diesel engines in the country manufacturing both high speed and medium speed engines. Low speed and medium speed engines are more suitable for CHP application. The major manufacturers in India are Kirloskar Pielstick, Garden Reach, K.G. Khosla and Wartsila. The new medium speed engines proposed to be manufactured in the country will be able to use heavy fuel oils of up to 700 centistoke (at 500$^0$C). These engines in the range of 4-6 MW would typically operate at an efficiency of 38-43%. In India, there are only a few installations of diesel engine based CHP systems with capacities up to 52 MW.

3.5 Waste heat boilers

The main manufacturers of waste heat boilers in the country are BHEL, Thermax, Cethar Vessels, ISGEC John Thompson, Texmaco, L&T, and Kaveri Engineering. Waste heat boilers of ratings up to 62 tph with single pressure and 105 tph with dual pressures are being manufactured in the country. Among smaller units, used for operation in a CHP system is a 38 tph waste heat boiler used to produce steam at a pressure of 15 kg/cm$^2$ and 2560C temperature. Installed in a refinery, it uses refinery gas as the heat source. However, most of these waste heat boilers have been supplied to fertilizer and chemical industries and refineries using process gas, natural gas and residual oil as the fuel.

The capability to manufacture fired waste heat boilers also exists in the country and the largest fired waste heat boiler supplied is a dual pressure boiler supplying saturated steam at 39 kg/cm$^2$ and 10 kg/cm$^2$.

4. Status of CHP technology-using biomass as fuel

At present there are only four major companies that can manufacture multi-fuel boilers at 43 atmospheres (ata) pressure and only two of them are now in the process of upgrading their facilities to 63 atmospheres. The 63 ata. boilers are fluidized bed boilers. Multi-fuel boilers will be required because bagasse will be available only for about 8 months in a year and the boiler may have to operate on coal or rice-husk for the remaining period to be cost effective. Boilers operating at pressures greater than 100 ata are not available in India for 50-100 MW plants.

There is hardly any CHP packager in India except for 3-4 for major engineering companies. The types of contracts that are required for successful execution and running of the plant are totally new to almost any company here in India. It is therefore, essential to generate adequate awareness in the companies about the practical aspects of CHP. There is also a problem of nonavailability of bagasse driers, which have moisture content of about 50%. All these factors can significantly affect the power generation.

5. Potential for CHP in India

There have been very few definitive studies to estimate the potential for CHP in Indian Sugar Industry. TERI has recently carried out a detailed survey of 300 industrial units covering 10 different industrial sectors in the country and estimated CHP potential based on the analysis of the data obtained from the questionnaires. The investment required for the steam or/and gas turbines for each of the sector was also studied under the study (refer table 1). The CHP estimates are based on the internal heat to power ratios, which would meet the plant's energy requirements and based on the existing production capacities of the various industry categories. Of the total estimated potential of 7,574 MW, nearly 68% is estimated to exist in the sugar industry alone. If the power maximization options were to be considered, the CHP potential is expected to increase significantly.

Table 1: CHP Potential in Indian Industry

| S.No | Industry | Potential (MW) | Investment for Turbines (Rs Million) |
|---|---|---|---|
| 1. | Alumina | 59 | 590 |
| 2. | Caustic Soda | 394 | 3940 |
| 3. | Cement | 78 | 780 |
| 4. | Cotton Textile | 506 | 5060 |
| 5. | Iron and Steel | 362 | 5430 |
| 6. | Fibres | 144 | 1440 |
| 7. | Paper | 594 | 5940 |
| 8. | Refineries | 232 | 3010 |
| 9. | Sugar | 5131 | 66700 |
| 10. | Sulphuric acid | 74 | 740 |
| | Total CHP Potential | 7574 | 93630 |

## 6. Barriers in adoption of CHP Projects

While the extent of conservation potential through total energy systems has been well appreciated, as also the numerous advantages one would derive from the concept, there are several barriers to CHP which restrict the adoption of such systems by the industries. Some of the important barriers are discussed below.

### 6.1 Technological constraints

CHP under the power maximization mode requires high pressure and high temperature system parameters. High-pressure boilers, turbines and accessories are not available in sufficient quantities indigenously (there are only six manufacturers of high-pressure boilers in India). Turbines at high pressure are presently imported.

### 6.2 Financial constraints

Investments required for the CHP systems are substantial. Often the industries find it difficult to raise resources for the incremental cost of setting up a CHP system with the objective to sell surplus power to the utilities. The tax and duty structure on the capital equipment used for the CHP facility are not as attractive as in case of other non-conventional energy sources. Liberal credit facilities such as concessional interest rates, larger repayment period etc. should be provided to the industries to encourage CHP. Also, multi-lateral and bi-lateral funding institutions must insist on promoting CHP when the loans for new power projects are negotiated.

### 6.3 Legislative constraints

Presently there is no legal framework for the purchase of surplus cogenerated power. Unlike the US where, under the PURPA, it is mandatory for the public utilities to buy the energy generated by the cogenerator at the avoided cost, there is no such requirement in India. Avoided cost is the incremental cost to the electric utility that the utility will either generate itself or purchase elsewhere if it did not purchase from the cogenerator. Few State Electricity Boards (SEBs) have encouraged CHP. In fact the self-generated sales tax imposed by the state tax authorities has acted as a disincentive for the industries to opt for CHP. Except for two or three SEBs, other utilities do not have any arrangements for wheeling and banking of cogenerated power. It is important to have long term purchase contracts between the SEBs and cogenerators for purchase of surplus power to encourage industries to opt for CHP under power maximization mode.

### 6.4 Pricing policy

One of the most crucial factor in promoting CHP relates to agreement on the tariff policy. There is no clear pricing policy for purchase of power. Utilities while carrying out their long term planning exercise, must consider CHP option as a source of firm power supply in relation to conventional power generation options. The tariff for cogenerated power should therefore be set at the avoided cost for new capacity added for meeting base load demand.

### 6.5 Grid related problems

The parallel operation of a generating unit presents several concerns for a utility. These include safety, power quality, reliability, protection of facilities, and planning or operating problems. The utilities must maintain the integrity of their systems in order to ensure a reliable supply of electricity to their customers. Therefore, any interconnected CHP system may include some equipment dedicated to protecting the utility from problems that may originate in the CHP system. There may also be problems of grid synchronization when the electricity cogenerated is at 11KV while the grid may need it to be fed in at 33/66 KV. All these factors may affect the economics of power generation in parallel operation with the grid.

### 6.6 Skilled manpower

High pressure and temperature cycles for increasing the power output from CHP plants require expert professionals to operate and manage the systems. Presently, industries operating CHP facilities at low pressure and temperature cycles do not have the required expertise. It is important that the industries undertake appropriate training for the professionals to operate the CHP systems efficiently.

## 7. Recent initiatives to promote CHP

The Government of India, Ministry of Non-Conventional Energy Sources, Power Group, vide their circular dated 5th January and 7th January, 1993 have announced financial incentives for (i) demonstration CHP projects in sugar mills and (ii) for the preparation of Detailed Project Reports for bagasse based CHP. A maximum of 2 demonstration projects would be sanctioned in each of the major sugar producing states subject to surplus power generated from cogenerators being allowed to supply to the SEBs or to other bulk electricity consumer.

### 7.1 Demonstration CHP project

Demonstration projects for bagasse based CHP will be provided with one-time non-recurring capital subsidy of 30% (maximum amount of Rs 70 lakhs per MW exported from the plant) of total equipment cost provided the project employs a minimum steam generation pressure of at least 60 kg/sq cm and a temperature of 450? C. It is imperative for the project to generate surplus power of at least 5 MW for sale to the SEBs or to another bulk electricity consumer for a duration of 24 hours per day for at least 160 days a year. Profitable sugar mills opting for demonstration projects should have achieved a capacity utilization of at least 80% in the last five years or during its operational period in the case of new plants. The proposal for demonstration project should also be supported by letter of approval from the SEB to the effect that it will be willing to wheel, bank or buy back electricity offered for sale or permit third party sale at remunerative prices. Independent power producers will also be eligible for the demonstration projects.

For CHP plants opting for dual fuel mode of operations, the subsidy will be given only on the bagasse fired capacity on the basis of maximum notional power generation of 3 MW per thousand tonnes of cane crushed per day or as indicated in the Detailed Project Report, which ever is lower.

### 7.2 Detailed Project Report

Detailed Project Reports (DPR) for bagasse based CHP will be provided with one-time grant-inaid to the extent of 50% of the actual cost of DPR or of projects employing 60bar and 40 bar pressure configurations, generating minimum surplus power of 5 MW and 4 MW respectively. The maximum assistance of Rs 4 lakhs and Rs 3 lakhs would be admissible under the programme.

### 7.3 Introduction of the two-part tariff system

The Ministry of Energy, under their policy decision to encourage private sector participation in power generation have introduced a two-part tariff system which would guarantee returns to the private investors. The first part of the tariff ensures recovery of fixed costs (including returns) based on performance at normative parameters. And the second part ensures meeting of variable expenses, based on units of electricity actually supplied. Incentives will be provided for the achievement of efficiency levels, higher than the normative parameters. Once the rate for sale of power is fixed, no limits of any sort will be put on actual profits earned by a generating company. The system also provides for the signing of a Contractual Agreement, laying down rates for the bulk sale of power by a generating company to an SEB for a specified period.

### 7.4 Increased role of private sector

To augment resources for the capacity development in the Indian power sector, the government has formulated a scheme to encourage greater participation by private enterprises in electricity generation, supply and distribution. The government has established an Investment Promotion Cell (IPC) in the ministry of power to coordinate and assist the private sector in the formulation and approval of projects. The new policy widens the scope of private investment in the sector by making modifications in the financial, administrative and legal environment. Some of the changes include the following:

i. The private sector can set up coal/lignite or gas-based thermal, hydroelectric, wind and solar energy projects of any size.

ii. Private sector can set up units either as "licensees" distributing power in a licensed area from own generation or purchased power; or as "generating companies,"generating power for supply to the grid.

iii. Licensees holding license to supply and distribute energy in a specified area issued by the State Government will function under a liberalized economic and legal environment.

iv. Captive Power Plants set up to serve an industrial or other units by the private sector will be permitted to sell or distribute the surplus power to the State Electricity Boards.

8.0 Conclusion

Industrial CHP has been the subject of considerable interest and inquiry in India for over a decade. The main arguments for CHP in India have centered on two compelling needs:

i) to augment supply of power inexpensively in a regime of endemic power shortages, and ii) to promote energy conversion efficiency and thereby conserve scarce fossil fuels. In other words, the debate, until now, has centered on the use of CHP to ensure reliable, continuous delivery of cost effective power and to reduce dependence on fossil fuels.

CHP in the sugar industry brings additional benefits. The carbon released to the atmosphere as $CO_2$ by CHP is no greater than what would have been produced by alternative methods of bagasse disposal (i.e., burning the bagasse inefficiently in the boilers or letting the bagasse decompose). Also, to the extent that CHP represents a good investment opportunity for sugar mills throughout India, it increases their financial health and the health of the agricultural sector as a whole.

To date, CHP in India has been restricted to the production of electrical energy for selfuse or "captive power" and has been viewed as a way to meet simultaneous on-site heat and power demands independently of the grid. Industries such as sugar, pulp and paper, and textiles have been "cogenerating" electricity and steam for many years. The location of these industries in regions removed from the grid (e.g., sugar mills and paper plants), the availability of by-product fuels (e.g., bagasse and black liquor), and the steam requirements of the industrial process all combined to favor CHP. Beginning from the mid-seventies, the number of industries favoring CHP has grown to include chemical producers, oil refiners, and fertilizer manufacturers. These industries possess large and simultaneous steam and power demands and have installed CHP units in order to insulate themselves from the undependable utility supplies and to reduce plant costs.

Despite an increased use of industrial CHP for captive power, there has not been equal action in areas such as policy and regulation to promote the use of these systems for commercial sale of electricity. Without any way to sell their electricity for a reasonable return, sugar companies and other potential cogenerators saw little reason to discard their present systems in favor of more efficient ones that produce power for export.