

Co-generation, Combined Heat and Power (CHP)

Name: Pandurang S. Jalkote, EA-0366
Designation: Addl. Manager (Operations & EMC)
Company name: Reliance Energy Ltd.
Address: C-11/9, DTPS, Dahanu Road, Dist: Thane- 401608
Fax no: (02528)222578, **Cell:** 9325119746
Email ID: jalkote@yaho.com , psjalkote@yaho.co.in



Contents:

1. Introduction.
2. What Is Co- Generation, Combined Heat and Power (CHP)?
3. Principle of Cogeneration, CHP.
4. Types of Co-generation, CHP Technologies.
 - 4.1 Backpressure technology.
 - 4.2 Extraction condensing technology.
 - 4.3 Gas turbine heat recovery boiler technology.
 - 4.4 Combined cycle technology.
 - 4.5 Reciprocating engine technology.
 - 4.6 Micro-turbines.
 - 4.7 Fuel cells.
 - 4.8 Stirling engine.
5. Usefulness of this technology.
6. Success stories/ failed/ barriers.
 - 6.1 Success stories.
 - 6.1.1 Rana sugars
 - 6.1.2 Sagar sugars.
 - 6.1.3 Godavari sugars.
 - 6.2 Barriers / failed.
 - 6.2.1 Grid Connectivity Issues in Sugar Mill Cogeneration.
 - 6.2.2 Operation and Maintenance of issues in Cogeneration Plants.
7. Suggestion/ comments/ recommendation.
8. Policies in support of CHP.
9. What is good and what requires improvement?
10. Conclusion.

1. Introduction:

Yes.....I, you, society, organization, state, nation and world need development. Not simply development but a Sustainable development and sustainable development benefits social, economic, technological, and environmental benefits. Power (electricity) and Heat plays a major role for development; it can accept all of us without any drought in our mind. To produce cheap electricity, lower emissions to the environment, in particular of CO₂, the main greenhouse gas, better cycle efficiency, improved local and general security of supply, electricity demand and supply and to increase employment we need better technology for generation of electricity. Yes... Cogeneration, Combined Heat and Power (CHP) can fulfill it for long way.

In India, power development is the joint responsibility of the Central and State government. In fact, Section 44 (1) of E(S) Act 1948 bars any licensee or any other person other than the government or a government corporation from setting up a generating station without the consent of the State Electricity Board (SEB) concerned, and Section 44 (2A) requires the SEB to consult the Central Electricity Authority (CEA) before issuing a consent for capacities more than 25 MW. In India, cogeneration is synonymous with captive generation.

2. What Is Cogeneration, Combined Heat and Power (CHP)?

Cogeneration or CHP (combined heat and power) is the simultaneous production of electricity and heat using a single fuel such as bagasse, natural gas, coal, waste gas, biomass, liquid fuels and renewable gases. The heat produced from the electricity generating process (for example from the exhaust systems of a gas turbine) is captured and utilised to produce high and low level steam. The steam can be used as a heat source for both industrial and domestic purposes and can be used in steam turbines to generate additional electricity (combined cycle power). Cogeneration for on-site power and heat is well established overseas, especially in

Scandinavian countries. Its use is gradually increasing in Australia, although optimistic forecasts of rapid implementation and growth in the last couple of years have yet to be realized.

3. Principle of Cogeneration, Combined heat and power (CHP).

The principle behind cogeneration is simple. Conventional power generation, on average, is only 35% efficient – up to 65% of the energy potential is released as waste heat. More recent combined cycle generation can improve this to 55%, excluding losses for the transmission and distribution of electricity. Cogeneration reduces this loss by using the heat for industry, commerce and home heating/cooling.

In conventional electricity generation, further losses of around 5-10% are associated with the transmission and distribution of electricity from relatively remote power stations via the electricity grid. These losses are greatest when electricity is delivered to the smallest consumers.

Through the utilisation of the heat, the efficiency of cogeneration plant can reach 90% or more. In addition, the electricity generated by the cogeneration plant is normally used locally, and then transmission and distribution losses will be negligible. Cogeneration therefore offers energy savings ranging between 15-40% when compared against the supply of electricity and heat from conventional power stations and boilers.

Because transporting electricity over long distances is easier and cheaper than transporting heat, cogeneration installations are usually sited as near as possible to the place where the heat is consumed and, ideally, are built to a size to meet the heat demand. Otherwise an additional boiler will be necessary, and the environmental advantages will be partly hindered. This is the central and most fundamental principle cogeneration.

When less electricity is generated than needed, it will be necessary to buy extra. However, when the scheme is sized according to the heat demand, normally more electricity than needed is generated. The surplus electricity can be sold to the grid or supplied to another customer via the distribution system (wheeling).

Cogeneration plant consists of four basic elements:

1. A prime mover.
2. An electricity generator.
3. A heat recovery system.
4. A control system.

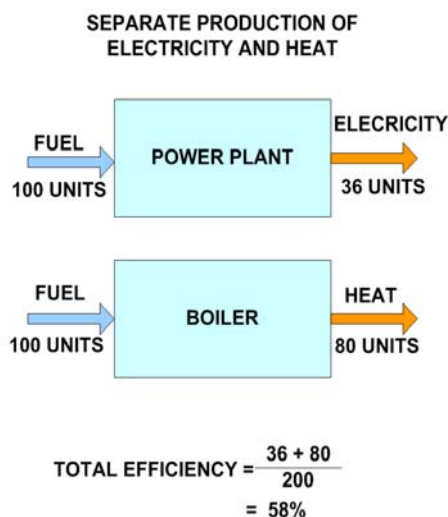


Fig.1: Separate production of Electricity & Power

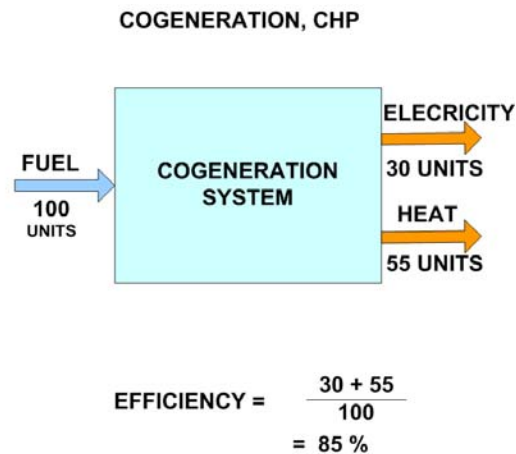


Fig.2: Cogeneration, Combined Heat and Power

4. Technologies in Cogeneration, Combined heat and power (CHP).

4.1 Backpressure Technology:

The first type of technology in cogeneration available was the Backpressure, where combined heat and power (CHP) is generated in a steam turbine. The Fig. 3 shows the process flow of backpressure type cogeneration (CHP).

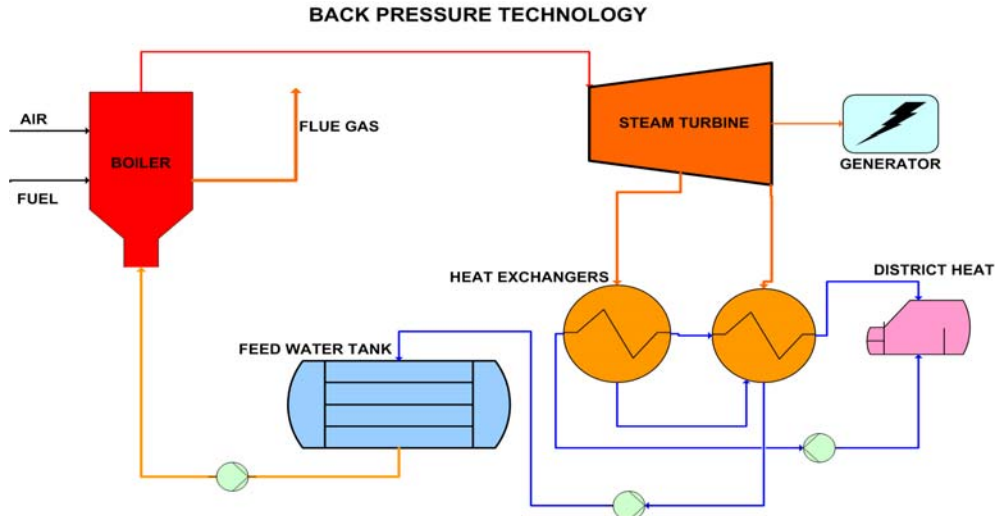


Fig. 3 Backpressure Technology.

4.2 Extraction Condensing Technology:

The second type of technology in cogeneration available was the Extraction Condensing. A condensing power plant is generating only electricity whereas in an extraction condensing power plant some part of the steam is extracted from the turbine to generate also heat.

The Fig. 4 shows the process flow of Extraction Condensing type cogeneration (CHP).

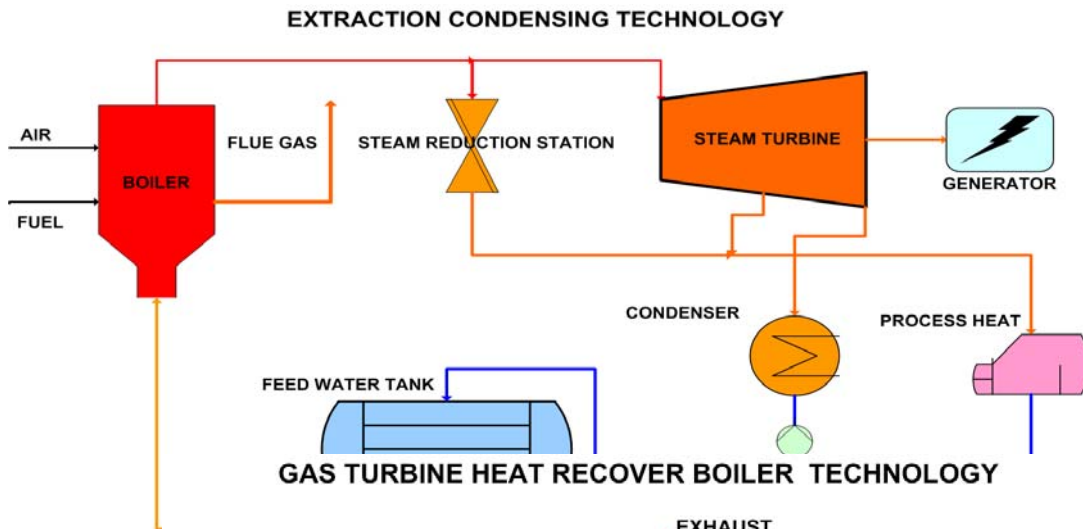
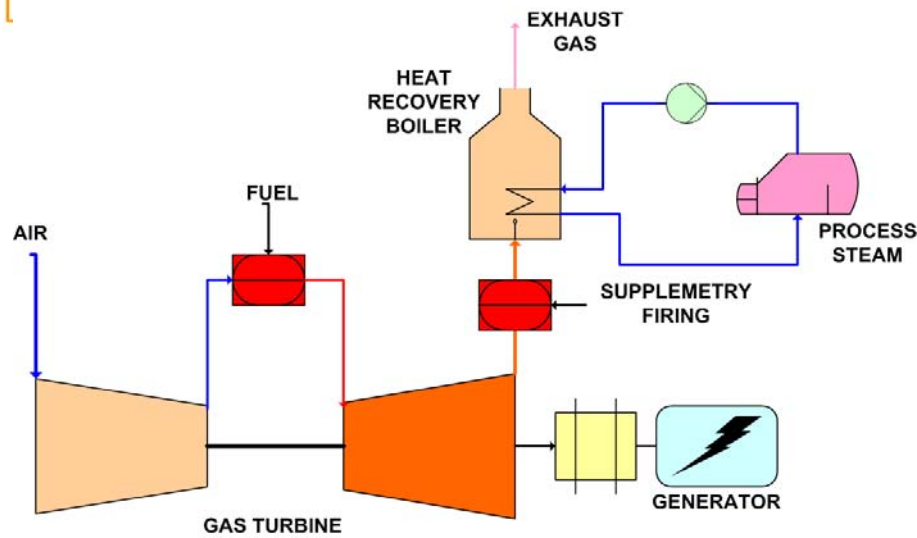


Fig. 4 Extraction Condensing Technology.

4.3 Gas Turbine Heat Recovery Boiler Technology:

Recovery turbine heat power plants generated with of the turbine. in most cases oil, or a these. Gas even be fired solid or liquid The process



The third type of technology in cogeneration available was Gas Turbine Heat Boiler. In gas recovery boiler heat is hot flue gases The fuel used is natural gas, combination of turbines can with gasified fuels. Fig. 5 shows flow of Gas

turbine Heat recovery boiler cogeneration (CHP)

Fig. 5 Gas Turbine Heat Recovery Boiler Technology.

4.4 Combined Cycle Technology:

The fourth type of technology in cogeneration available was Combined cycle. A combined cycle power plant consists of one or more gas turbines connected to one or more steam turbines.

The Fig. 6 shows the process flow of Combined Cycle cogeneration (CHP).

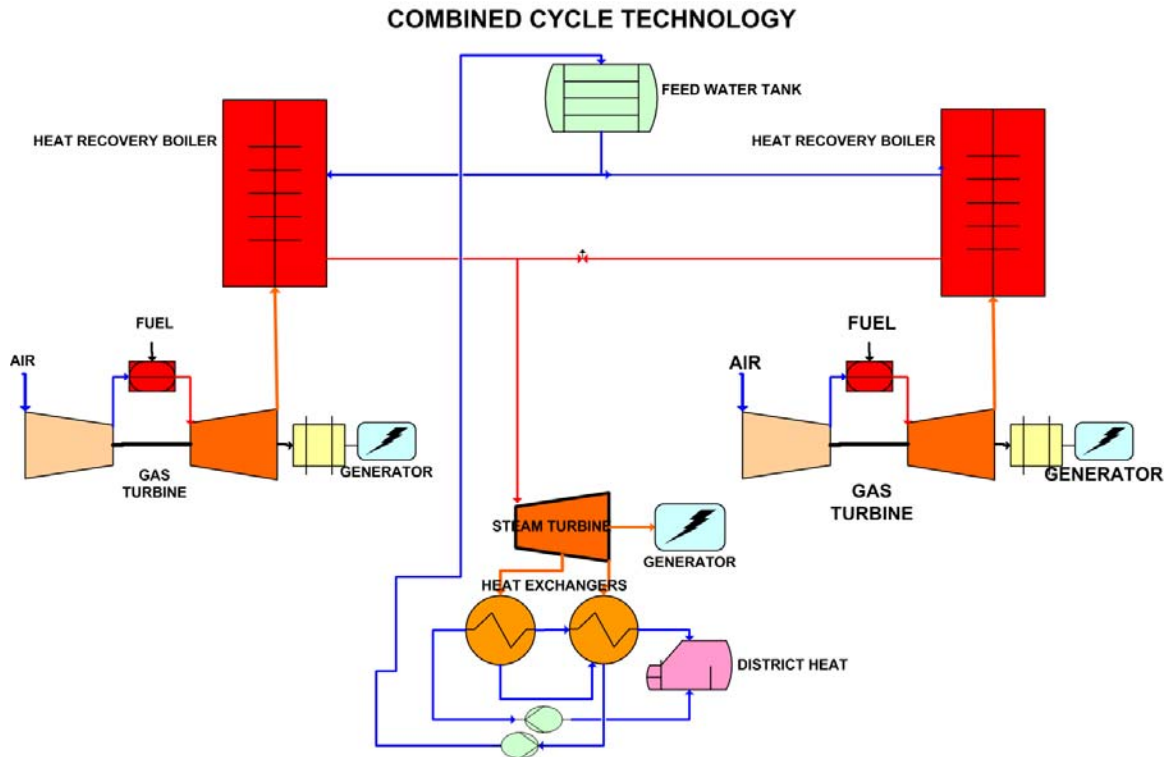


Fig. 6 Combined Cycle Technology.

4.5 Reciprocating Engine Technology:

The fifth type of technology in cogeneration available was Reciprocating Engine. Instead of a gas turbine, a reciprocating engine, such as a diesel engine, can be combined with a heat recovery boiler, which in some applications supplies steam to a steam turbine to generate both electricity and heat. In a reciprocating engine power plant heat can be recovered from lubrication oil and engine cooling water as well as from exhaust gases.

The Fig. 7 shows the process flow of Reciprocating engine cogeneration (CHP).

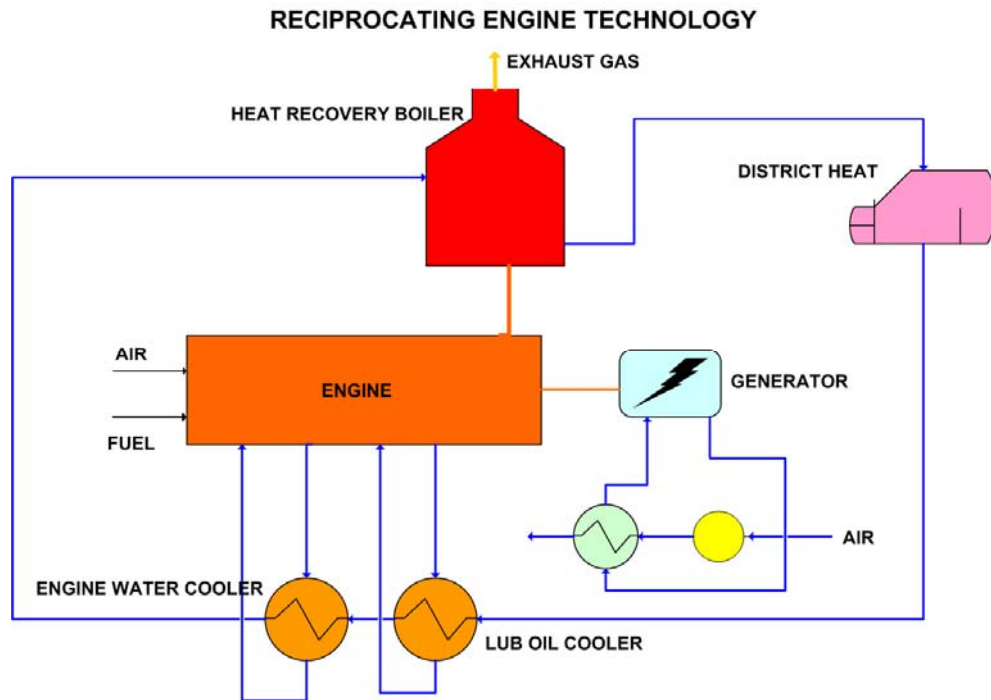


Fig. 7 Reciprocating Engine Technology.

Above technologies are readily available, mature, and reliable. Three other technologies have recently appeared on the market, or are likely to be commercialized within the next few years:

4.6 Micro-turbines:

This new type cogeneration technology to be commercialised. Micro-turbines are smaller are smaller than conventional reciprocating engines, and capital and maintenance costs are lower. There are environmental advantages, including low NO_x emissions of 10-25 ppm (O₂ – 15% equivalent) or lower.

Micro-turbines can be used as a distributed generation resource for power producers and consumers, including industrial, commercial and, in the future, even residential users of electricity. Significant opportunities exist in five key applications:

- Traditional cogeneration,
- Generation using waste and bio-fuels,
- Backup power,
- Remote Power for those with “Black Start” capability,
- Peak Shaving.

4.7 Fuel cells:

Fuel cells convert the chemical energy of hydrogen and oxygen directly into electricity without combustion and mechanical work such as in turbines or engines. In fuel cells, the fuel and oxidant (air) are continuously fed to the cell. All fuel cells are based on the oxidation of hydrogen. The hydrogen used as fuel can be derived from a variety of sources, including natural gas, propane, coal and renewable such as biomass, or, through electrolysis, wind and solar energy.

A typical single cell delivers up to 1 volt. In order to get sufficient power; a fuel cell stack is made of several single cells connected in series.

Even if fuelled with natural gas as a source of hydrogen, the emissions are negligible: 0.045 ppm NO_x, 2 ppm CO, 4 ppm HC.

A number of different types of fuel cells are being developed. The characteristics of each type are very different: operating temperature, available heat, tolerance to thermal cycling, power density, tolerance to fuel impurities

etc. They are also in very different stage of development and some of them have not emerged from the laboratory. Some are approaching commercial breakthrough. This will be covered by other briefings from COGEN Europe.

4.8 Stirling engines.

The Stirling engine is an external combustion device and therefore differs substantially from conventional combustion plant where the fuel burns inside the machine. Heat is supplied to the Stirling engine by an external source, such as burning gas, and this makes a working fluid, e.g. helium, expand and cause one of the two pistons to move inside a cylinder. This is known as the working piston. A second piston, known as a displacer, then transfers the gas to a cool zone where it is recompressed by the working piston. The displacer then transfers the compressed gas or air to the hot region and the cycle continues. The Stirling engine has fewer moving parts than conventional engines, and no valves, tappets, fuel injectors or spark ignition systems. It is therefore quieter than normal engines, a feature also resulting from the continuous, rather than pulsed, combustion of the fuel.

There are some low capacity Stirling engines in development or in the market. The electrical efficiency is still not very high and in the range of 10% (350 We engine); 12.5% (800 We engine) up to 25% (3,000 We engine), but it should be possible to design them with at least 25% electrical efficiency and total efficiency of 90%.

5.0 Usefulness of this technology.

Cogeneration involving simultaneous generation of multiple useful energy sources viz. power, heat, refrigeration / cooling, water recycling, Evaporation and Drying.

Industries go for Cogeneration due to following principle reasons.

- a) To reduce power and other energy costs.
- b) To improve productivity and reduce costs of production through reliable uninterrupted availability of quality power from Cogeneration plant.
- c) Cogeneration system helps to locate manufacturing facility in remote low cost areas.
- d) Improves energy efficiency, and reduces CO₂ emissions therefore it supports sustainable development initiatives.
- e) The system collects carbon credits which can be traded to earn revenue.
- f) Due to uninterrupted power supply it improves working conditions of employees raising their motivation. This indirectly benefits in higher and better quality production.
- g) Cogeneration System saves water consumption & water costs.
- h) Improves brand image and social standing.
- i) Cogeneration is the most efficient way of generating electricity, heat and cooling from a given amount of fuel. It saves between 15-40% of energy when compared with the separate production of electricity and heat.
- J) Cogeneration helps reduce CO₂ emissions significantly. It also reduces investments into electricity transmission capacity, avoids transmission losses, and ensures security of high quality power supply.
- k) A number of different fuels and proven, reliable technologies can be used.
- l) A concurrent need for heat, electricity and possibly cooling indicates suitable sites for cogeneration.
- m) The initial investment in cogeneration projects can be relatively high but payback periods between 3-5 years might be expected.
- n) The payback period and profitability of cogeneration schemes depends crucially on the difference between the fuel price and the sales price for electricity.

o) Global environmental concerns, ongoing liberalization of many energy markets, and projected energy demand growth in developing countries are likely to improve market conditions for cogeneration in the near future.

6.0 Success stories/ failed/ barriers.

6.1 Success stories:

6.1.1 Rana Sugars

Rana Sugars Ltd (Rana) in Amritsar district, Punjab had a licensed cane crushing capacity of 2,500 TCD, which was expanded to 5,000 TCD in 1997-98. They implemented an advanced cogeneration project using a 1x10 MW extraction-cum-condensing turbine and a boiler of 62 kg/cm², 480oC and 55 tph capacities. The 66-kV switchyard was commissioned in January 2001 in the first phase, and Rana was exporting power with the existing 6- MW double extraction-cum-back- pressure turbine. In the second phase, the 55 tph boiler and 10 MW turbines were commissioned in February 2002, and commercial operations began in March 2002.

Accomplishments

By 18 March 2003, the cogeneration plant had successfully operated for 272 days between March 2002 and March 2003 (198 days in the crushing season and 74 days in the off-season) using only bagasse (183,822 tons) and other biomass such as rice, mustard, and wheat husk (20,580 tons). About 83% of its fuel requirement was met from in-house bagasse and the remaining was met from purchased biomass. The average cost of rice husk was Rs. 1,750/ton and that of wheat/ mustard husk was Rs 1,150/ton (including transportation costs). During the 272-day operation, Rana generated 65 million kWh of electricity, out of which 41 million kWh was sold to the Punjab State Electricity Board (PSEB). The gross generation has improved to 82 kWh/t from 53 kWh/ton of cane crushed. The revenue realized from surplus power export was Rs 1,340 lakh at the rate of Rs 3.16/kWh up to March 2002, and at the rate of Rs 3.32/kWh for the remaining period. CO₂ offset from gross power generation was 71,404 tons, and from net power generation using biomass fuel was 44,684 tons.

6.1.2 Sagar Sugars:

Sagar Sugars and Allied Products Ltd, (SSAPL), promoted by the Mohan Breweries and Distilleries Ltd Group of Companies (MBDL), was granted a license to set up a 2,500 TCD sugar plant in Nelavoy village, Sri Rangarajapuram Mandal, Chittoor District, Andhra Pradesh, along with other downstream industries.

The management of SSAPL, realizing the potential available for cogeneration and surplus power export to the grid, decided to implement a cogeneration project with an 80 tph, 66 kg/cm², 485oC boiler and a 20 MW extraction-cum -condensing turbine. Sagar commissioned the cogeneration plant on 8 January 2003, and plans to commission the sugar mill and a distillery of 70 klpd by January 2004.

Besides receiving financial assistance from USAID ís GEPABC Project, SSAPL has taken a loan from IREDA for setting up their sugar mill cogeneration project. It has already received approvals from related government agencies.

SSAPL entered into a Power Purchase Agreement with Andhra Pradesh Transmission Company (APTRANSCO) to export power. SSAPL erected the 132 kVA transmission line with 62 x 132 kV double circuit towers to the Kothapallimitta sub-station under APTRANSCOís supervision, which is about 19 km from the sugar mill.

Status

After undertaking boiler and turbo generator trials and commissioning, the cogeneration plant was synchronized with the APTRANSCO grid on 7 January 2003 and full load was achieved the next day. The cogeneration plant was commissioned on 8 January 2003 and commercial operation began on 13 January 2003. As on 18 March 2003, the cogeneration unit had generated 275.86 lakh kWh and exported 251.69 lakh kWh to APTRANSCO, earning a revenue of Rs 833.54 lakh. The average loading was maintained at 18 MW, and export was maintained at 16 MW.

The open storage yard has a capacity of 20,000 tons of bagasse. The plant had tied up with Prudential Sugars and Sri Venkateswara Cooperative Sugars for the supply of 60,000 tons of bagasse during this season. Sagar plans to purchase 45,000 tons of bagasse from Gayatri Sugars and 100,000 tons of biomass fuel, such as wood chips, through biomass dealers. Sagar also plans to develop about 1000 acres of wasteland in nearby districts aiming at an average yield of 30 MT/acre (Subabul plantation).

6.1.3 Godavari Sugars:

The Godavari Sugar Mills Ltd, Sameerwadi, Karnataka, has a present crushing capacity of 8,500 TCD. The management conceived the idea of setting up a 24 MW high-efficiency cogeneration plant in 1997.

BSES Noida was the EPC contractor for the cogeneration project, and Desein (P) Ltd was the project consultant and also the Operations & Maintenance (O&M) contractor for the project for five years. Such an EPC/O&M contract for a cogeneration project was undertaken for the first time in India. The 24 MW cogeneration plant was synchronized with the Karnataka Power Transmission Corporation (KPTCL) grid through a sub-station at Mahalingpur on 16 March 2002. Commercial operation commenced from April 9, 2002.

There is a captive consumption of 6 MW during the season and 3 MW in the off-season and the balance is exported to the KPTCL. Apart from power generation, the cogeneration plant also meets part of the steam requirements of the sugar factory and distillery.

The total project cost of Rs 108 crore was met with loans (Rs 74 crore) from IDBI, Andhra Bank and the State Bank of India (SBI), while the equity was met (Rs 34 crore) with the USAID GEP-ABC grant of Rs 4.2 crore.

The plant is fully automatic with state-of-the-art technology including triple modular redundancy in all controls. The plant also incorporates the latest version of distributed control systems (DCS).

Special Features of the Cogeneration Plant

- The highest capacity bagasse-fired boiler in India.
- Turnkey EPC/O&M contract for the first time in India.
- Fully automatic plant with logic redundancy for all critical controls.
- Mechanized bagasse stacking.
- Modern fire-fighting system.

6.2 Barriers/failed:

6.2.1 Grid Connectivity Issues in Sugar Mill Cogeneration.

The qualifying requirements for a process to be termed as cogeneration shall be determined in accordance with the Ministry of Power Resolution No. A-40/95-IPC-I dated 6.11.96.

Status and Selling Arrangements

Cogeneration plants may have different status with regard to use of power for own consumption during their off-season:

- Generating and selling power during the season and meeting their off -season requirement through captive DG sets.
- Being a regular consumer of the distribution licensee and selling power to the licensee from their surplus generation, and meeting their own consumption requirement from the licensee whenever in deficit.
- Though not a regular consumer of the licensee, but meeting their requirement in an emergency from the licensee grid.
- Supply directly to a consumer.

The status of cogeneration in this respect is different in different states. Some states have allowed even captive plants installed for dedicated use or on a consortium basis to sell excess power to the licensee. The practices regarding voltage levels at which such plants get connected to the licensee grid are also different in different states.

Preferred Voltages

The distribution licensee generally prefers to have power at voltages higher than the distribution voltage with the sole aim that the power is received at some grid substation of the licensee and could be distributed/regulated as desired.

Connectivity Concerns

whereas there is no complexity in the arrangement where the Co generator is supplying power directly to a consumer, other arrangements are not simple. The connectivity of power generated from a cogeneration plant with the grid substation of the licensee involves the following issues:

- Mode of operation, synchronous or radial
- Quantum of power to be supplied
- Location of consumption centers
- Power availability in the state
- Cost of the system and interfacing

Impacts

Whether the cogeneration plant has to run in synchronous mode or has to feed some loads radially would be a major factor in deciding the connectivity. If the power to be supplied by the Co generator into the grid is of small quantum, the licensee may not be interested in purchasing it. If interested, it has to analyze if such energy is not wasted in incremental line losses itself. Again, if the energy so supplied is consumed at places far off from the point of supply, it would not be of much value for the licensee.

If the state has surplus power then it may opt for purchasing power from a Co generator for selling it outside the state and the connectivity would have to be looked into accordingly.

The cost of laying evacuation lines up to the point of exchange is a major factor in deciding the connectivity with the grid. The effort of the Co generator would always be to supply their power to the nearest available point at whatever voltage it may be and without any consideration whether it is the 'out' point of a substation or a tapping point in between. The less invested on the evacuation system, the greater the economic viability and profits.

The practice generally opted for costs of transmission lines and synchronization equipment is that they would be borne by the Co generator. However, as the cost of construction of 132 kV and above lines is very high it may be shared by the Co generator and Purchaser, but the work will be carried out under the supervision of the Purchaser/Licensee. The minimum capacity may be fixed beyond which such arrangement would be agreed to.

Connectivity

The widely preferred mode of connectivity is as below:

Up to 10 MW - on 33 kV

Above 10 MW - on 132 kV

The power from the Co generator is transmitted at 33/132 kV voltage through a 33/132 kV line from the mill. The power so transmitted will be interfaced with the Purchaser's 132 kV or higher voltage grid substation.

In case of evacuation of power to the grid substation through a 33 kV line, the full cost of the 33 kV line would be borne by the Co generator. In case of evacuation through a 132 kV or higher line, it becomes difficult for the Co generator to bear the cost, and as such the cost of the 132 kV or higher voltage line from the plant to the designated substation of the Purchaser is decided mutually. In Uttar Pradesh, the entire cost of interfacing at both ends (the mill and UPPCL), the Transmission System, including work at the UPPCL substation, cost of bay, tie-line, if any, and replacement/up-gradation of existing equipment, if any, would be borne by the Co generator. Whereas the 132 kV line cost is shared equally. The work relating to transmission and interfacing within the mill premises would be done by the Co generator.

The construction of the transmission line and other supporting works indicated above, as the case may be for evacuation of power, shall be done by the Purchaser/or Co generator as mutually decided. The technical and other work specifications shall be finalized with the Purchaser/Licensee's approval in accordance with standards and specifications. The construction of 132 kV or higher voltage line, for which the cost of line is shared, shall generally be done by the Purchaser/Licensee, or the Co generator at the Purchaser's discretion. Such a line constructed for evacuation of power from the plant, shall not be used for transmitting/supplying power for any other purpose, without mutual agreement between the Co generator and the Purchaser. Existing transmission/distribution lines of the Licensee/Purchaser may be utilized for evacuation of power from the plant to the Grid Substation on mutual agreement.

Regulatory mechanisms have added a new dimension to this issue as all these arrangements are to be approved.

System Maintenance

The maintenance of equipment at the generating end shall be done by the plant to the satisfaction of the Purchaser. The maintenance of 33/132 kV or higher voltage lines and terminal equipment at the Purchaser substation shall be done by the Purchaser, annual maintenance charges being payable by the Co generator.

Any work to be done by the Co generator shall only be with specific approval of the Purchaser or Regulatory Commission as the case may be.

Without limiting the foregoing, the Co generator and Purchaser shall install, operate and maintain the interconnection and parallel operation facility in accordance with accepted good engineering practices in the electricity industry and Electricity Grid Code.

Protective Equipment & Interlocking

The interconnection facilities shall include necessary protective equipment and interlocking devices, which shall be so coordinated that any malfunctioning or abnormality in the generators or in the bus of the motor controller shall not adversely reflect on or affect the grid system. In the event of any malfunctioning or abnormality, the system shall be designed to ensure that the Co generator breaker isolates its system.

Arrangements at the Point of Supply

The Co generator shall make all arrangements for paralleling the set/s with grid in consultation with, and to the satisfaction of the Purchaser, subject to various safety codes.

Synchronization

The mill would synchronize its power generating set with the Purchaser's system with all due care and notice to the Purchaser.

The Purchaser would not be responsible for the damage, if any, caused to the plant and equipment of the Co generator due to failure of the synchronizing or protective system provided by them.

Metering

The Co generator shall provide two identical sets of Time of Day (TOD) frequency sensitive static meters, with the facility for downloading data to measure the quantity and time details of the power exported and imported, conforming to the specifications approved mutually along with all necessary associated equipment. These meters shall be installed at the interconnection point or as mutually agreed. One set of export/import meters shall be termed the "Bill Meter" and the other set the "Check Meter." The complete metering system consisting of meters, current and potential transformers shall conform to the 0.2 accuracy class, individually and collectively, and shall comply with the technical standards accuracy and calibration requirements of the Indian Electricity Rules and the specifications of the Bureau of Indian Standards.

Operation

The operation of the system would be done as per instruction from the Load Control Center, which in case of the State Licensee is the State Load Dispatch Center. The Availability Based Tariff regime coming in to field and with more consciousness of commercial interests on the part of the Co generator as well as the Purchaser, sensitivity of parameters has taken a front seat and is to be taken care of in the best possible manner.

6.2.2 Operation and Maintenance of issues in Cogeneration Plants

The 24-MW cogeneration plant of Godavari Sugar Mills at Sameerwadi, Dist. Bagalkot, Karnataka is the most modern plant installed in the sugar sector by Desein Private Ltd. as Owner Consultant. Desein was awarded the Operation & Maintenance (O&M) activity of the plant to be carried out by their expert team of engineers, technicians and associated staff. The plant's instrumentation and control system Desein Distributed Control Management Information System (DDCMIS) is designed to control and monitor the process parameters to ensure smooth, safe and reliable plant operation. Normal control/supervision of the boiler function, steam turbine generator and other plant auxiliaries are carried out through the DDCMIS. Off-site packages such as the bagasse handling system, Demineralizer (DM) and ash handling plants are provided with independent Programmable Logical Controller (PLC) systems and are connected to the DDCMIS via a serial communication network.

The operation of a sugar mill cogeneration plant is entirely different from a captive power plant operated on coal or oil as fuel. Maintaining and controlling fire in the furnace is easier with such fuels, while in bagasse-fired

boilers maintaining uniform fire depends on continuous regulation of bagasse to the furnace through its feeding system. Feeding of excess bagasse to its feed system beyond the firing rate may result in choking of chutes/feeders resulting in loss of fire and tripping of the plant at low temperatures. Operation of the plant through milled bagasse during the crushing season, and through purchased bagasse during the off-season has its own operating problems, which may result in choking of chutes and jamming of the furnace stoker and hence should be carefully looked into. In a nutshell, the smooth operation of a sugar cogeneration plant is entirely dependent on proper operation of the bagasse handling system.

O&M Elements

Administrative Control

For proper administration, labor should be properly selected with experience in the same type of plant. Shift routines are to be planned considering leave schedules.

Liaison with plant owner regarding requirement and supply of process steam for the sugar plant, generation, availability, plant shut down for various maintenance/overhaul activities. A good operator studies the requirement trend and plans changes in the operating procedure and maintenance schedule to ensure good operation and availability of equipment. It is necessary to keep a close track of efficiency of the generating facility and organize corrective measures whenever required. Regular review of spare stock versus the requirement on the basis of planned shutdown and lead time to be made is required. Spares should be properly preserved during storage. A Master Library with drawings, O&M and spare parts manuals, plant commissioning and performance reports should be set up for effective operation and maintenance.

For Administrative Control, a logging practice should be followed, some of which are given below:-

- Attendance Register/Identity Cards: To record daily attendance, and casual, sick and earned leave availed by employees.
- Operation Status Log Sheets covering
 - Daily units generated
 - Daily bagasse consumed
 - Total power generation
 - Total Auxiliary Power Consumption of the cogeneration plant
- Bagasse Inventory Data Sheets
- Occurrence Report - occurrence in any system resulting in loss of power generation
- Relay Setting Forms
- Accident Report Form
- Safety Manuals

A small reference book which will list Safety Practices should be followed for safe isolation of mechanical and electrical equipment including high voltage, safety rules, instructions, First Aid in case of accident, rules of fire fighting and disaster management, etc.

Operation Control

Under Operation Control there should be regular walk-around inspections and visual condition/monitoring of each equipment in operation and operating parameters should be recorded on the log sheets. Each starting operation and shut-down should be recorded in the station log book and "Occurrence Reports" for any unforeseen tripping and shut down should be prepared. Safe isolation of equipment being released for repair/servicing by the maintenance department should be carried out. Safety tags as per safety instructions and issue "Release Permits" should be installed.

Proper interaction is needed with transmission authorities for Load Dispatch and maintenance department and revises setting of protection relays to match with changes in fault levels as and when necessary.

For Operation Control, a logging practice should be followed, some of which are given below:-

- **Shift In-charge Log Book:** For entry of General Conditions and comments by shift in-charge engineer during his shift
- **Operator's Log Book:** To record entire operation of SG/TG, general defects, equipment released for maintenance, etc. during his shift. Similar log book to be maintained for other auxiliaries.
- **Switchyard Log Book:** To record switching carried out and other communication concerning load dispatch
- **Bagasse Area Log Book:** To record arrival of bagasse, operation of bagasse handling system release of any equipment for maintenance and other communication.
- **Equipment Release Register:** To record date and time of release of equipment, list of isolating and safety tagging points, person to whom released and time and date of release of equipment back in operation.
- **STG Set Log Sheet:** To record hourly parameters of various mechanical instruments and electric meters of SG and TG. One log sheet for each day of operation to be maintained.
- **Switchyard Log Sheet:** To record reading on hourly basis of various indicating instruments and energy meters of each MV switchgear and 110 kV line.
- **Fuel Yard Log Sheet:** To record daily log of contents and one sheet per day of operation to be generated
- **Defects Reporting Forms:** One form for each type of defect during shifts and at the night shift will be sent to the maintenance department for necessary action.

Maintenance Control

For maintenance control, daily preventive maintenance activities as per schedule and immediate action in case of trouble shooting, and attending mechanical and electrical faults should be carried out.

For effective maintenance, a computerized system of preventive maintenance based on recommendations by the manufacturer, site conditions and past experience with similar equipment should be prepared. This system should schedule each maintenance activity, list out probable spares and consumable and manpower requirements, etc.

Protection relays, gauges, energy meters are to be regularly calibrated within expiry date. To minimize downtime, record of quality of oil of distribution transformer and other HV/MV transformers are kept so that filtration activities are planned along with plant maintenance.

For Maintenance Control, a logging practice should be followed, some of which are given below:-

- **Annual Maintenance/Overhaul Schedule:** This should be followed for power stations for individual equipment.
- **Inspection Schedule:** To follow the annual plan for inspection of individual equipment as per local regulations and statutory requirement from insurance companies.
- **Cardex for Equipment:** A cardex for each piece of plant should be maintained. This should include brief specification, serial number, manufacturer information, inventory number, where installed; a list of daily/weekly/monthly/bi-annual/annual checks, when last carried out, when next planned, etc.
- **Cardex for Spares:** A cardex for each type of spares in inventory to be maintained which should have reference to the manufacturer part number, specification, quantity required, lead time, etc.
- **Cardex for Protection Relays:** A card for each electrical protection relay to be maintained which will have a serial number, specification, where installed, last date of calibration and testing, due date for next, and brief history of any problem/malfunction
- **Cardex for Energy Meters:** A card for each energy meter similar to protection relays should be made. This should also have calibration curve of these meters attached with the card.

Last, but not the least, plant and equipment need to be regularly dusted and painted with epoxy paint for its longevity to minimize the corrosion effect of bagasse since flying bagasse is a great nuisance, which deposits on plant and equipment.

7.0 Suggestion/ comments/ recommendation.

“Cogeneration, the path to profit and sustainable development”

Cogeneration is the simultaneous production of power and heat - usually in the form of electricity and steam.

Benefits are much higher fuel efficiency and lower environmental load compared with the levels achievable with purchased electricity and independent steam generation.

With solid fuels, high pressure steam is usually raised in a boiler and passed through a turbine to generate power. The low pressure turbine exhaust steam is then available for process heating.

With liquid and gaseous fuels, it is also possible to run a reciprocating or gas turbine engine to generate power from the hot pressurised gases and then recover exhaust heat for process use.

Cogeneration will reduce the gap between demand and supply of electricity. So, this technology can be implementing compulsory in following field.

Industrial

- Pharmaceuticals & fine chemicals
- Paper and board manufacture
- Brewing, distilling & malting
- Ceramics
- Brick
- Cement
- Food processing
- Textile processing
- Minerals processing
- Oil Refineries
- Iron and Steel
- Motor industry
- Horticulture and glasshouses
- Timber processing

Buildings

- District heating
- Hotels
- Hospitals
- Leisure centres & swimming pools
- College campuses & schools
- Airports
- Prisons, police stations, barracks etc
- Supermarkets and large stores
- Office buildings
- Individual Houses

Renewable Energy

- Sewage treatment works
- Poultry and other farm sites
- Short rotation coppice woodland
- Energy crops
- Agro-wastes (ex: bio gas)

Energy from waste

- Gasified Municipal Solid Waste
- Municipal incinerators
- Landfill sites
- Hospital waste incinerators

8.0 Policies in support of CHP.

8.1 Cogenerators as Power Producers: Policy Perspectives

In India, power development is the joint responsibility of the Central and State government. In fact, Section 44 (1) of E(S) Act 1948 bars any licensee or any other person other than the government or a government corporation from setting up a generating station without the consent of the State Electricity Board (SEB) concerned, and Section 44 (2A) requires the SEB to consult the Central Electricity Authority (CEA) before issuing a consent for capacities more than 25 MW. In India, cogeneration is synonymous with captive generation.

SEBs grant their consent only when it is not possible for them to supply the same power within the next 24 months, or if it is not possible for the licensee or any other person other than the government or a government corporation to obtain it more economically within a reasonable time from another appropriate source. As such there was no concrete policy for the development of captive generation/cogeneration.

The power sector was considered a core sector for accelerated development under the various Five-Year Plans. However, by 1991 the country was facing acute energy shortages (7.9%) and peaking shortages of 16.7%. Until 1991, the public sector was being funded mainly through budgetary support and external borrowings. The growth of the economy called for commensurate growth in infrastructure facilities.

It was realized that it is no longer possible to continue with the practice of budgetary support due to growing demand of other sectors, basically the social sector, and on account of severe borrowing constraints. Thus efforts were initiated in 1991 to bring private sector into generation to supplement the efforts of the public sector. A new policy framework was established and the Indian Electricity Act, 1910 and Electricity (Supply) Act, 1948 were suitably amended in October 1991 to facilitate the entry of private generating companies. Several incentives were offered to the private sector.

Despite best efforts and policy initiatives at the Government level, various measures have not given desired results. There has not been significant investment coming to the sector. Large capacity additions were not expected due to long gestation periods of large plants and it was expected that the country would face huge energy shortages of the order of 15% and peaking shortages of 30% by the end of 1996-97.

Thus there was a need to open an alternative route other than private generating companies, where the industries themselves will be interested in meeting their own power demand by pooling resources together. Captive/cogeneration power plants offer such an alternative.

With the setting up of Regulatory Commissions in 1998 at the Center and State level, these have to play a prominent role and provide support to the state government at the policy front.

Central Government Policy Initiatives

The Center asked all state Governments in October 1995 for the first time to create an institutional mechanism allowing captive/cogeneration power plants an easy and automatic entry through quick clearance, rational tariff for purchase of surplus power by the grid, and third party access for direct sale of power to other industrial units. The Center notified a resolution on "Promotion of Cogeneration Power Plants" on 6 November 1996. The basic features are:

- It recognized the importance of cogeneration and emphasized its development with the combined objectives of promoting better utilization of precious energy resources in industrial activities and creation of additional power generation capacity in the system.
- Captive power plants of any other persons (including juristic persons and excepting generating companies) are not subject to the provisions of Section 29(2) of the E(S) Act.
- It recognized that industry in general and a process industry in particular needs energy in more than one form, and if the energy requirements and supply to the industrial units are carefully planned overall efficiency of a very high order is possible to achieve.
- Emphasis on institutional mechanisms highlighting the issues involved.
- Two basic cogeneration cycles have been identified:
- Topping Cycle - Any facility that uses fuel input for power generation and heat for other industrial activities. In any facility with a supplementary firing facility, it would be required that the useful heat to be utilized in the industrial activities, is more than the heat to be supplied to the system through supplementary firing by at least 20%.
- Bottoming Cycle - Any facility that uses waste industrial heat for power generation by supplementing heat from any fossil fuel.

Qualifying Requirements

A facility may qualify to be termed as a cogeneration facility if it satisfies certain operating and efficiency standards.

Qualifying Requirements for Topping Cycle:

- It depends on the type of fuel used as the overall efficiency levels likely to be achieved for power generation varies with the choice of fuel. For coal and refinery bottoms, the sum of useful power output and one half the useful thermal output should be greater than 45% of the facility's energy consumption. For liquid fuel, the sum of useful power output and useful thermal output should be greater than 65% of the facility's energy consumption.
- The Facility must be able to supply at least 5 MW of power for at least 250 days in a year.

Qualifying Requirements for Bottoming Cycle:

The total useful power output in any calendar year must not be less than 50% of the total heat input through supplementary firing.

Benefits of Cogeneration Systems:

- High efficiency - by utilizing the same fuel to provide heat and electricity, and thereby reduce fuel consumption, fuel cost, electric utility bills, and provide economic competitive advantages through a maximized return on investment capital;
- More useful energy due to recovery of otherwise wasted heat; and energy conservation;
- More environment friendly because of efficient fuel use and reduced air emissions (GHG, sulfur dioxide, nitrogen oxides, particulate) and reduced thermal pollution;
- A reliable source of power and process steam or heat. This is particularly important in regions prone to frequent disruptions in electricity supply;
- Onsite electricity generation can eliminate losses (8-10%) in the transmission and distribution systems; and
- Low gestation period.

Foreign Investment Policy

- Foreign investors can enter into a joint venture with an Indian partner for financial and/or technical collaboration and also for setting up renewable energy-based power generation projects.
- Liberalized foreign investment approval regime to facilitate foreign investment and transfer of technology through joint ventures.
- The proposals for up to 74% foreign equity participation in a joint venture qualify for automatic approval.
- 100% foreign investment as equity is permissible with the approval of the Foreign Investment Promotion Board (FIPB).
- Various Chambers of Commerce and Industry Associations in India can be approached for providing guidance to investors in finding appropriate partners.
- Foreign investors can also set up a liaison office in India.
- Government of India is also encouraging foreign investors to set up renewable energy based power generation projects on Build Own and Operate (BOO) basis.

Policy Initiatives at State Government Level

- For encouraging investment by the private and public sector companies in power generation through renewable energy, a set of guidelines have been issued by the Ministry of Non-Conventional Energy Sources for consideration by the States.
- In addition, some States are providing concession/ exemption in State Sales Tax and Octroi, etc.
- Maharashtra allows projects on a co-operative basis also and the Maharashtra State Electricity Board provides equity participation.
- Karnataka extends a subsidy of Rs 2.5 million/MW.

The Need for Cogeneration:

- When it makes economic sense to the industry.

- The cost of power supplied by the utility is more than the cost of generation by the cogeneration power plant.
- The utility is not being able to provide reliable enough or good quality power causing inconvenience/loss to the industry.
- Driven by efficiency considerations.

Wheeling @ 2%	AP, Haryana, Kar, (6%), Mah., UP, TN, Punjab, Rajasthan
Banking 8-12 months	AP, Haryana, Kar, Mah., UP @ 2% (24 Months), TN, MP, Punjab, Rajasthan
Third Party Sale	AP, Haryana, Kar, Mah., MP, Punjab, Rajasthan
Buy-Back Rs 2.25 per kWh (1994 Base Year)	AP, Haryana, Kar, Mah., UP, TN, MP, Rajasthan
Annual Escalation 5%	AP, Haryana, Kar, Mah., UP, TN, MP, Rajasthan

AP - Andhra Pradesh; Kar - Karnataka; UP - Uttar Pradesh; TN - Tamil Nadu; MP - Madhya Pradesh; Mah - Maharashtra

Current Scenario in Cogeneration Facilities

- Stand-alone Plants - Meeting emergency or captive requirement of industry with or without parallel operation with the State Grid
- Plants having surplus/excess capacity over and above captive requirement of industry requiring parallel operation with the grid
- Backup supply from the utility is required in most cases

Issues Involved

- Price of power exchanged
- Apportionment of cost between thermal and power output
- Return to cogenerator.
- Discounting of benefits to the utility as well as cogenerator
- Stranded cost to utility and under-utilization of transmission assets of the utility
- Avoidable cost to the utility

The SERCs have to look at the pricing issues in a proper perspective. Backup power supply arrangement with the utility and settlement of accounts, parallel operation with the grid, compatibility with the State Grid and its safety, wheeling of power, banking arrangements with the utility, and third party sale of power.

8.2 Govt. of Tamilnadu policy:

In June, 1993, the state government announced a new policy on independent power production based on the recommendations of the joint committee. The policy included:

- A price for cogenerated power equal to the tariff charged by the State Electricity Board to industry consumers in the state, less 2% for the cost of transmission. The State Electricity Board will pay cogenerators Rs. 1.80 (approximately 5.8 U.S. cents) per kWh, double the rate that was initially offered, and this rate will increase as the HT-1 tariff is periodically raised.
- Elimination of the tax on self-generation, both for captive power and for power export.
- Approval of wheeling of power at rates mutually agreed upon by the cogenerators and the private third parties. The State Electricity Board will charge a fee in the form of 10% of the wheeled power. The State Electricity Board will also "bank" power for later consumption by the cogenerator in return for 2% of the electricity.

8.3 Govt. of Uttar Pradesh policy:

The U.P Government, in order to encourage bagasse based cogeneration in sugar mills, has declared an attractive policy which includes:-

- Buy back rate of Rs. 2.25 per unit. All energy transactions to be settled on monthly basis.
- Wheeling and banking for up to one year to own and other units in other parts of the State allowed at attractive rates.
- Third party sale allowed at mutually agreed rate through own transmission/distribution lines.
- Policy is applicable to other biomass based power generation project also.

9.0 What is good and what requires improvement?

There is an opportunity for Cogeneration when there is a simultaneous requirement for power and heat.

Modern schemes can have considerable flexibility in the ratio of power to heat provided and may be configured to meet the usual electrical load requirement - with supplementary and standby power from the grid, and with supplementary heat from additional boilers.

Meeting the cyclic demands of large batch processes is awkward - cogeneration sits most comfortably with continuous processes or activities with relatively steady demands.

A fuel or fuels need to be available, competitive with the delivered cost of essentially coal-based electricity. Understanding the economics of a cogeneration proposal is difficult at present, due to uncertainty in the future electricity and gas tariffs. This is a considerable stumbling block.

Small scale cogeneration facilities may be owned, operated and financed by the energy host organisation. Then relatively simple economic evaluation and investment approval processes can be used.

Specialist cogeneration companies exist who can assist with evaluation, equipment selection and operation of cogeneration facilities.

The fuel supplier, and electrical energy supply authority will also be involved in providing tariff information and scoping and evaluating the project, and agreeing arrangements for purchase of any excess power supplied into the grid, and for sale of supplementary or stand-by requirements from the grid.

Large scale projects with shared users and substantial electricity sales are much more complex. The evaluation, technology selection, approval, financing and operating arrangements is all quite complex, with many different possibilities. The relationships between the many different parties have to be defined in contractual agreements, which need to provide for all kinds of future possibilities.

Even the economic evaluation is difficult to define at present, with a wide range of future power and fuel prices suggested by different "experts".

A large cogeneration facility will involve at least the following parties and agreements:

- Host - services agreements for purchase of electricity and steam. The host may have equity participation.
- Electricity Distributor - power purchase and standby power supply agreements.
- Investors - equity funds
- Financiers - loan funds
- Operator - operation and maintenance functions. May also be an equity participant.
- Prime Contractor - engineering design, supplier selection, procurement and construction.
- Fuel Supplier - long term contract.
- Consultants - for technical, environmental, financing and legal matters are also likely to be involved.

10.0 Conclusion

Amongst all the countries, next to China, India has to sustain the largest population of over 960 million. It is unfortunate that the per capita electricity available for consumption in India is 315 Kwh only, which is one of the lowest in the World. Therefore, until and unless electricity generation is increased 7 to 8% annually, the requisite growth in the national economy at the annual rate 7% cannot be sustained.

Electricity generation in India has to depend primarily on coal since India has very low reserve of other fossil fuels and natural gas. The Electricity generation from other sources like Hydel and Nuclear resources has not made sizable contribution. The Non-Conventional energy resources have also not been developed enough to make any appreciable contribution. Therefore, serious effort has to be made to use well proven and reliable technology i.e. Cogeneration Combined Heat and Power (CHP).

Thus, in power sector, huge capital investments are required to be made for their proper development. Since 1991, the Government of India has taken steps to open up the Indian economy in order to attract private and foreign investments. Though foreign investments have been flowing in, the pace has rather been slow since there are lots of procedural bottlenecks which need to be streamlined by the Government.