

**CO-GENERATION & COMBINED HEAT AND POWER (CHP) SUCCESS STORIES/
FAILED/ BARRIERS, SUGGESTION/COMMENTS/ RECOMMENDATION TO MAKE THIS
TECHNOLOGY IMPLEMENTABLE IN INDUSTRIES.
PRESENT POLICIES IN SUPPORT OF CHP.**

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“Co-generation & Combined Heat and Power (CHP)”

Cogeneration or Combined Heat and Power (CHP) is defined as the sequential generation of two different forms of useful energy from a single primary energy source, typically Mechanical energy and thermal energy. It 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.

CHP is ...

- an integrated system,
- located at or near a building or facility,
- satisfying at least a portion of the facility's electrical demand, and
- utilizing the heat generated by the electric (or shaft) power generation equipment to provide heating, cooling, and /or dehumidification to a building and/or industrial processes.

CHP systems can be broadly categorized into two groups –

Topping cycle: The primary fuel is used to produce electricity and the thermal energy exhausted is used for process heating. Topping cycle cogeneration is widely used and is the most popular method of cogeneration.

- Combined-cycle topping system: A gas turbine or diesel engine producing electrical or mechanical power followed by a heat recovery boiler to create steam to drive a secondary steam turbine.
- Steam-turbine topping system The second type of system burns fuel (any type) to produce high-pressure steam that then passes through a steam turbine to produce power with the exhaust provides low-pressure process steam.
- A third type employs heat recovery from an engine exhaust and/or jacket cooling system flowing to a heat recovery boiler, where it is converted to process steam / hot water for further use.
- Gas-turbine topping system. A natural gas turbine drives a generator. The exhaust gas goes to a heat recovery boiler that makes process steam and process heat.

Bottoming cycle: 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. Bottoming cycles are suitable for manufacturing processes that require heat at high temperature in furnaces and kilns, and reject heat at significantly high temperatures.

Availability of Cogeneration Systems

Proven, commercially available cogeneration technologies

- Steam turbine (ST) cogeneration system
- Gas turbine (GT) cogeneration system
- Combined cycle gas turbine (CCGT) cogeneration system
- Internal Combustion Engine cogeneration system
- Steam Engine cogeneration system

Other “less” commercially available cogeneration technologies:

- Integrated Gasification Combined Cycle (IGCC)
- Micro-turbines
- Fuel cells
- Stirling Engines

Major CHP Components

- Prime Mover Technologies
- Heat Recovery Technologies
- Thermally-Activated Technologies

Selection of Cogeneration System

The specific components comprising a CHP plant will, however, depend upon:

- Industry,
- Energy conversion system, and
- Strategy picked for sizing the energy conversion system.

Technical Parameters influencing the selection of Co-Generation system are

For selecting the most viable configuration from the application point of view, multiple technical parameters need to be considered. All of them have a direct or indirect bearing on the commercial scope of the project influencing certain environmental aspects of the plant.

Heat to Power Ratio

The ratio of generated power to the generation of heat/steam on the basis of the same energy unit is called the power-to-heat ratio. When equal amounts of power and steam are generated the ratio is 1, when more steam than power is generated the ratio is < 1. The characteristics of different cogeneration systems vary. The choice of technology will always correspond with the end-user application. If, for example, the demand for steam in the process is higher compared to the power demand, a system with lower Power-to-Heat ratio is recommended.

System	Range	Cogeneration Efficiency(%)	Typical Overall Eff	Typical Power to Heat Ratio (PHR)
Steam Turbine	0.4-300 MW _e	10-45	< 80%	0.15-0.75
Gas Turbine	0.5-300 MW _e	25-40	65-80%	0.45-0.75
Combined Cycle	10-300 MW _e	35-50	75-90%	0.75-1.70
Internal Combustion Engine	1 KW _e - 15MW _e	25-45	65-85%	0.50-1.80
Steam Engine	20 KW _e - 2 MW _e	5-25	70-80%	0.10-0.45
Micro Turbine	20-250 KW _e	25-30	50-80%	0.55-0.76

Efficiency

The *overall efficiency*, or *cogeneration efficiency*, is a measure on how much usable energy is generated from a specified amount of fuel. This does not give a clear picture of individual properties for electricity and steam or heat. Therefore, the efficiency for a cogeneration system must be separated into power and overall efficiency. If power generation is the major output of the application, it is pragmatic to consider the power efficiency factor though, sometimes, a lower overall efficiency could still be accepted in such cases.

Reliability and Availability

Reliability of a system is definitely one of the top priorities in the design of power systems. It ranks on par with cost and efficiency as a measure of successful design. The focus on reliability has developed from the need for identifying the least reliable components within a given complex system. Reliability can be defined as “the likelihood or probability that, the equipment will “do its job” for a specified length of time under specified circumstances. The usual definition is real operation time in relation to planned operation time.

Reliability = (to – tf) / to

where

to = Planned operation time

tf = Forced outage time

In some applications the availability gives a better measurement of the plants functionality. Availability is “a measure of the degree to which an item is in an operable and committable state at the start of a mission, when the mission is called for at an unknown (random) time”. One usual definition of availability is the ratio between real operation time and planned operation time plus planned overhaul and maintenance time:

$$\text{Availability} = (t_o - t_f) / (t_o + t_m)$$

Where

t_o = Planned operation time

t_f = Forced outage time

t_m = Planned outage time overhaul and maintenance

Quality of Power generation

The two main electricity quality parameters in a power system are *voltage* and *frequency*. Interruptions and variation from distributed generators could cause fluctuations and problems in the grid. The availability and stability of power generation are important factors particularly for on-site electricity consumption (within the industry) and when delivering to the grid.

Quality of Thermal Energy

Depending on the application, the requirements for thermal energy will vary in temperature and pressure and consequently, the selection of cogeneration system too. The amount of possible power generation, as well as usable heat is more or less dependent on the heat quality requirements. For example, high temperature supply requirement from steam turbine system will lead to high backpressure and thereby reduce power generation and electrical efficiency.

Fuel Flexibility

Fuel flexibility has become more important since the availability, fuel prices, fuel taxation, emission restrictions and subsidies have changed significantly over the past years in Europe. High fuel flexibility offers economical options and also contributes significantly for energy supply security. An industrial cogeneration plant that is using residue products from the industry itself as fuel must consider the fact that the fuel quality can vary. The cogeneration system should be designed for the expected variation without loss of reliability. In order to increase the energy supply security a backup fuel such as oil, could be advisable for biomass and gas fuelled plants.

When using fuels like natural gas or coal the variations in fuel composition are normally negligible. The demand for fuel flexibility is therefore less significant. Future access and pricing of the fuel are difficult to predict. A possibility of maintaining a certain level of fuel flexibility for a particular cogeneration system reduces the potential risk posed otherwise by shortage or availability irregularities.

Fuel supply security

An industry installation must not jeopardize the main production. When using the residue products as fuel there might be variations both in quality and fuel availability. For effective energy generation, and also the production, it is favorable to secure the fuel supply for a certain time period. When there is risk of supply irregularities, minimizing such potential risks by local storage and an arrangement for an alternative fuel could be better options. The viability of such arrangements could be further cross-checked by comparing the costs incurred for these alternatives versus the opportunity costs incurred during production loss in case of fuel shortage.

Partial load efficiency

The usage pattern for the industry determines the plant part-load characteristics. A variable demand can be accommodated at different part-loads during long periods. To maintain optimal plant efficiency under these conditions it is essential to ensure acceptable part-load efficiency. It's of vital importance to design the plant congruous to actual load and not on the basis of part-load as providing for them which may actually affect the plant efficiency. Normally an Internal combustion (IC) Engine is superior to gas and steam turbine based systems in efficiency at part-loads. At a 40 % load, an IC Engine can present more than 90% of its full load efficiency.

Robustness against net irregularities

One of the reasons for having in-house cogeneration can be to have reliable continuous supply of power and steam for the production process avoiding power failure from grid or other insecurities. For this reason plants with these kinds of circumstances must be able to operate independent from the power grid. Also the plant must be able to start-up without grid connection.

Operation and Maintenance

Operation and Maintenance (O & M) set high demands on documentation of the design, machine details and working patterns of the plants mainly when they have to be operated by personnel who are less familiar with the steam and power productions. Operating instructions must be detailed and instructive. Unscheduled maintenance is potentially a large cost for the industry particularly when the machines come to a grinding halt. Maintenance is best practiced when done by local personnel themselves. Dependencies on external maintenance services are always time consuming and therefore become expensive. Maintenance manuals need to be descriptive and written in a language simple enough to be understood and communicable. Training of personnel responsible for O & M of the plant shall be part of the delivery.

Automation level and monitoring

Automation level is connected to the personnel requirements but also operation economy, availability and environmental performance. Automatic monitoring of general conditions, vibrations, emissions, chemical analysis, etc, with feedback for control and maintenance planning is of great importance for maximum utilization of the plant.

Other technical factors affecting the selection of Cogeneration technology are

- Quality of Thermal Energy Needed
- Load Patterns
- Grid Dependent System Versus Independent System
- Retrofit Versus New Installation
- Electricity Buy-back
- Local Environmental Regulation

Selecting an energy efficient cogeneration system to meet industrial process needs is very important. "Does cogeneration really offer an effective way to conserve energy requirement on both power and heat while reducing the energy costs per unit of product?" In fact, there is no simple answer to the question. A cogeneration plant is capital intensive. The matching process is critical when developing cogeneration to satisfy both heat and power requirements. Optimization of design is an issue that has to be taken into consideration on how to meet the needs of the industrial process and should be economically viable within a certain limit. Evaluation of energy requirements is the first step of the design. Accurately tracking the system demands will eventually result to a better cogeneration implementation rather than other cases. The energy requirements in factory can be obtained through an evaluation of the data recorded in terms of the pattern in electrical and thermal loads. The electrical and thermal loads can vary over a wide range. This may be due to various factors such as process changes, air conditioning requirements, or seasonal changes.

Electricity: The electricity consumption in kWh is normally recorded over a 24-hour period on hourly, daily and monthly bases.

Steam/load: The heat demands in kg of steam or m³ of hot air at different temperature levels are recorded on hourly, daily and monthly bases.

Cooling: The cooling demands in kg of chilled water or cooled air at different temperature levels are recorded on hourly, daily and monthly bases.

The actual load patterns, electrical and thermal, will be used to estimate the heat-to-power ratio of every period of each day. The maximum and minimum values of heat-to-power ratio are recorded to identify the type of cogeneration system that is best suited.

The heat-to-power ratio and vice versa is a function of many factors and must be determined on a case-by-case basis. This will be used for the selection of the appropriate cogeneration technology. To some extent, the choice is not at all straightforward where the coincidence between power and heat demand is poor. In some industries, for example, seasonal effects (such as high electricity demand, low heat utilization in summer and the reverse in winter) play a major role.

Such cases leave a cogeneration with three options:

- Operate as an island, and meet both heat and power demands or,
- Meet the power demand at all times and generate associated steam or,
- Meet the steam demand at all times and generate the associated electricity

Steam turbines may be the appropriate choice for sites where:

- Electrical base load is over 250 kWe
- There is a high process steam requirement; and heat-to-power demand ratio is greater than 3:1
- Cheap, low-premium fuel is available
- Adequate plot space is available
- High grade process waste heat is available (e.g. from furnaces or incinerators)

- Existing boiler plant is in need of replacement
- Heat-to-power ratio is to be minimized, using a gas turbine combined cycle

Gas turbines may be suitable if:

- Power demand is continuous, and is over 1 MWe (smaller gas turbines are just starting to penetrate the market)
- Natural gas is available (although this is not a limiting factor)
- There is high demand for medium/high pressure steam or hot water, particularly at temperature higher than 140°C
- Demand exists for hot gases at 450°C or above – the exhaust gas can be diluted with ambient air to cool it, or put through an air heat exchanger

Reciprocating engines may be suitable for sites where:

- Power, or processes are cyclical or not continuous
- Low pressure steam or medium or low temperature hot water are required
- There is a low heat: power demand ratio
- When natural gas is available, gas powered reciprocating engines are preferred
- When natural gas is not available, fuel oil or LPG powered diesel engines may be suitable
- Electrical load is less than 1 MWe - spark ignition (units available from 3 kWe to 10 MWe)
- Electrical load greater than 1 MWe - compression ignition (units from 100 kWe to 20 MWe)

Relevance of Cogeneration:

Cogeneration offers an attractive solution to meet the industrial energy requirements in an efficient manner, while conserving the national resources. Cogeneration offers numerous direct benefits to industry and institutional applications, but also positive carry-over benefits to utilities and the society at large.

Cogeneration Opportunities for utilities

- Reduce energy costs Enhance revenues
- Offer fuel flexibility
- Protect the company from power interruptions
- Increase power quality
- Offer short-up times
- Reduce wastes

Cogeneration Opportunities for utilities

- Defer capacity needs
- Reduce line losses
- Reduce risk
- Expand business opportunities

Cogeneration Opportunities for Society and Ratepayers

- More efficient use of resources
- Reduce emissions
- Lower electricity rates
- Increase employment
- Reduce utility debt

Typical cogeneration applications

Industrial: Wood and agro-industries, food processing, pharmaceutical, pulp and paper, oil refinery, textile industry, steel industry, cement industry, glass industry, ceramic industry

Residential, commercial & institutional: Hospitals, schools & universities, hotels, houses & apartments, stores & supermarkets, office buildings

District Heating & cooling: Airports, office & commercial buildings, dwellings and houses

Few Examples are listed below

Ex1: Gas cogeneration in Kuala Lumpur International Airport

40 MW natural gas cogeneration (or Jet A1 fuel)

- Gas Turbine Generator 2 x 20 MW
 - Heat Recovery Steam Generator 2 x 40 tph
 - Auxiliary Gas Boiler 2 x 25 tph & 1 x 40 tph
- Chilled water 30,000 RT

- Steam Absorption Chiller (12 x 2,500 RT)
Operation since 1997

Ex2: Gas cogeneration in Petronas Tower, Kuala Lumpur

25.8 MW natural gas cogeneration

- Gas turbine generator 2 x 4.2 MW & 2 x 8.7 MW
- Heat Recovery Steam Generator 2 x 10.7 tph & 2 x 18.7 tph
- Auxiliary gas boiler 2 x 47 tph

Chilled water 30,000 RT

- Electrical Centrifugal Chiller 3 x 5,000 RT
- Steam Turbine Centrifugal Chiller 3 x 5,000 RT
- 4 km chilled water network of pipes

Operation since 1996

Ex3: Hybrid cogeneration industrial estate

514 MW cogeneration

- Gas turbines 6 x 35 MW
- Steam turbines 2 x 152 MW
- Circulating Fluidized Bed Boilers
- Heat Recovery Units

Fuels: Natural gas, bituminous coal, Diesel oil (back up)

Operation since 2000

Supplies

- Electricity, steam (200 tph) and demineralised water (150 m3/h) to industrial estate and the plant
- Electricity to grid

Traditionally, refineries, fertilizer plants and sugar plants have cogenerated power and heat requirements for various industrial processes, but without exporting to the grid. There are several chemical and petrochemical processes that generate large quantum of waste heat, which could be utilized for electricity generation. Given the suitability of cogeneration to industry in India, the candidates for cogeneration would include industries with substantial combined heat and power requirements, such as sugar, textile, paper, fertilizer, food processing, chemicals and petrochemicals. Cogeneration is already being practiced widely in various industries such a pulp and paper, rayon, sugar, chemicals, and fertilizers.

Usefulness of Cogeneration in Industry

Typical example of Ammonia Urea Complex can be taken to understand the usefulness of Cogeneration. For 1550 MTPD Ammonia and 2620 MTPD of Urea Plant requires 10MW of Power and around 140 MT/hr of HP Steam.

Source of HP Steam

Waste Heat Boilers 275 MT/Hr (105ata 505°C)

Source of Power & MP Steam (Gas Turbine Generator + Heat Recovery Unit)

Gas Turbine Generator (GTG)	10 MW
Rated Capacity	15 MW
Heat Recovery Unit (HRU) Boiler	150 MT/Hr (41 ata 380°C)

Steam user of 275 MT/hr HP steam is typically Synthesis Compressor where extraction @ of 230MT/hr at 41 ata, 380°C is taken out. MP steam is used for process as well as for running compressors (Air, Refrigeration, CO2 etc) and Pumps (Cooling water, BFW, Process Streams).

Scheme1 for optimized utilization of existing Cogeneration system

To balance out the steam requirement and ammonia plant reliability 2No Cooling water pumps were run by Condensing turbines and standby pump was motor driven. Typical incremental specific inputs for producing power and steam from GTG/HRU are 1.1Gcal/MWh of power and 0.8 Gcal / MT of steam. As the margin was there in GTG the condensing turbine of Cooling water pump was replaced with motor with following saving in energy.

Total input steam:	4.0 MT/hr
Power Output to Pump	1.0MW
Total Heat Input to Turbine	3.2 Gcal /Hr (0.8Gcal/MT of Steam)
Replacement with Motor of	1.0 MW
Total Heat Input to Motor	1.1 Gcal /Hr (1.1 Gcal/MWh)

Energy saving with replacement	2.0 Gcal/Hr
Energy cost	Rs 500/Gcal
Annual Savings @330days operation	500 x 2.0 x 24 x 330 (Rs 80.0 Lacs)

Scheme2 for optimized utilization of existing Cogeneration system

3.5 ata steam is utilized to heat urea stream in vacuum evaporation section. A pre-concentrator was installed to utilize MP section process stream heat, which was being rejected to Cooling water to heat the urea stream in vacuum evaporation section. This has resulted in reduction of LP steam by 200Kg/MT of Urea or around 20MT/Hr of LP steam will become surplus by installation of Pre-Concentrator. Unless this is integrated within the complex no benefit will be accrued. In ammonia Plant requirement of LP steam was met by backpressure turbine running with 40-ata steam and outlet steam at 3.5 ata. Backpressure turbine was replaced with motor (0.8MW) to run the pump as the margin was available in the GTG to integrate the rendered surplus LP steam in Urea Plant.

In modern Ammonia / Urea fertilizer complex Cogeneration is used as follows;

- 1 Gas Turbine Generator (GTG) / Heat Recovery Unit (HRU) for meeting Power and Steam requirement.
- 2 Gas Turbine for Air Compressor along with Heat Recovery Unit.
- 3 Generating HP steam from HRU and matching typical Heat and Power requirements of complex to reduce the condensing steam in turbines.

Cogeneration Potential in Indian Industry

The estimated potential of cogeneration is between 17,000 to 20,000 MW, based on conservative estimates.

Industry	Potential (MW)
Alumina	59
Caustic soda	394
Cement	78-100
Cotton textile	506
Iron & steel	362
Manmade fibres	144
Breweries	250-400
Coke oven batteries	200
Commercial sector	175-350
Dairies	70
Distilleries	2900
Fertilizer	850-1000
Petrochemical	250-500
Plywood manufacturing industry	50
Rice mills	1000
Solvent extraction	220-350
Sponge iron	225
Tyre plants	160-200
Paper & pulp	850
Refineries	232
Sugar	5200
Sulfuric acid	74-125
Total	14628-15586

Key Factors for Financial Attractiveness of CHP in Industry / Facility

- Coincidence of Need for Electric Power & Thermal Energy - The more a facility needs electricity at the same time it needs thermal energy (heating, cooling, or dehumidification), the more attractive the savings and payback associated with CHP become.
- "Spark Spread" – The higher the differential between the cost of buying electric power from the grid and the cost of natural gas / fuel, the more attractive the savings and payback associated with CHP become.
- Installed Cost Differential – The lower the differential between the installed costs of a CHP system and that of a conventional system, the more attractive the savings and payback associated with CHP become.

Barriers to CHP

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.

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.

Financial constraints

Investments required for the CHP systems are substantial. The CHP projects are characterized by higher First Cost with under Estimating CHP Value and unfavorable utility tariffs. 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 should be provided to the industries to encourage CHP.

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.

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.

CHP in Indian industries

Industrial sector is one of the largest consumers of electrical energy in India. However, a number of industries are now increasingly relying on their own generation (captive and cogeneration) rather than on grid supply, primarily for the following reasons:

- Non-availability of adequate grid supply
- Poor quality and reliability of grid supply
- High tariff as a result of heavy cross-subsidization

As a result, the captive and cogeneration potential has been increasing over the years and it is estimated that nearly 30 per cent of the requirements of the industrial sector is met from in-house generation. Some of the recently published statistics indicate a captive power potential to the tune of 12,000 MW and cogeneration potential of 15,000 MW. Looking at the trends in generation capacity additions in the public and private sector, the role and significance of captive and cogeneration are expected to increase in the coming years.

The state governments and the state electricity boards (SEBs), aware of their inability to meet the needs of the industry in the immediate future have also been taking various policy initiatives to promote captive power production and cogeneration. At the same time they are also concerned with the impact of a high growth of captive power production and cogeneration on the deteriorating finances of the SEBs, the environment and the optimal growth of the power sector in the long run. The policies adopted by different states, based on the prevailing situation and their perceptions on achieving a balance of interests, are, therefore, not uniform.

Policy Guide Lines as per Tariff Policy

Captive generation is an important means to making competitive power available. Appropriate Commission should create an enabling environment that encourages captive power plants to be connected to the grid. Such captive plants could inject surplus power into the grid subject to the same regulation as applicable to generating companies. Firm supplies may be bought from captive plants by distribution licensees using the guidelines issued by the Central Government under section 63 of the Act.

The prices should be differentiated for peak and off-peak supply and the tariff should include variable cost of generation at actual levels and reasonable compensation for capacity charges.

Alternatively, a frequency based real time mechanism can be used and the captive generators can be allowed to inject into the grid under the ABT mechanism. Wheeling charges and other terms and conditions for implementation should be determined in advance by the respective State Commission, duly ensuring that the charges are reasonable and fair. Grid connected captive plants could also supply power to non-captive users connected to the grid through available transmission facilities based on negotiated tariffs. Such sale of electricity would be subject to relevant regulations for open access.

Non-conventional sources of energy generation including Co-generation:

(1) Pursuant to provisions of section 86(1)(e) of the Act, the Appropriate Commission shall fix a minimum percentage for purchase of energy from such sources taking into account availability of such resources in the region and its impact on retail tariffs. Such percentage for purchase of energy should be made applicable for the tariffs to be determined by the SERCs latest by April 1, 2006. It will take some time before non-conventional technologies can compete with conventional sources in terms of cost of electricity. Therefore, procurement by distribution companies shall be done at preferential tariffs determined by the Appropriate Commission.

(2) Such procurement by Distribution Licensees for future requirements shall be done, as far as possible, through competitive bidding process under Section 63 of the Act within suppliers offering energy from same type of nonconventional sources. In the long-term, these technologies would need to compete with other sources in terms of full costs.

(3) The Central Commission should lay down guidelines within three months for pricing non-firm power, especially from non-conventional sources, to be followed in cases where such procurement is not through competitive bidding.

Tariff design : Linkage of tariffs to cost of service

It has been widely recognized that rational and economic pricing of electricity can be one of the major tools for energy conservation and sustainable use of ground water resources.

Direct subsidy is a better way to support the poorer categories of consumers than the mechanism of cross-subsidizing the tariff across the board. Subsidies should be targeted effectively and in transparent manner.

For achieving the objective that the tariff progressively reflects the cost of supply of electricity, the SERC would notify roadmap within six months with a target that latest by the end of year 2010-2011 tariffs are within $\pm 20\%$ of the average cost of supply.

Recommendations /suggestions:

- Industry should be encouraged to implement CHP projects. Total benefit from CHP can be taken only if adequate Heat and power usage is integrated in the design stage itself. Larger industries like refineries, fertilizer and petrochemical plants have integrated the CHP in the design stage itself. However a group of industries in the common vicinity of say 1Km area can come together to implement a CHP project taking into consideration the individual power and heat requirement. This concept can be implemented by forming a separate CHP entity, which will provide heat and power to the participating industry.
- Supportive Tariff structure for surplus power produced by cogeneration facilities
- Risk sharing in case of non-availability of fuel, change in variable cost due to switching of fuel after entering into power purchase agreement (PPA), etc.
- Adequate wheeling and banking facilities.
- Lower contract demand charges.
- Rational level of duties and taxes on sale of power.
- Wheeling losses shall be minimum for power to be sold to grid by captive or cogen plant.
- Restrictions on the minimum amount of power to be wheeled.
- Charges for back-up or stand-by power from the grid at appropriate rates in case of failure of Cogeneration facility.
- Formal policy for purchase of co generated power.

