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FOR ENERGY MANAGEMENT AND EFFICIENCY PROFESSIONALS

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IMPORTANT TECHNICAL PARAMETERS FOR
COGENERATION
FOR ENERGY PROFESSIONALS
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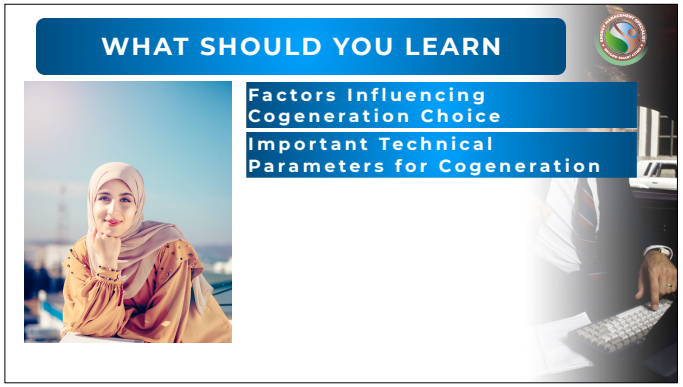
ENERGY SPECIALIST CURRICULUM


WHAT SHOULD YOU LEARN
Factors Influencing Cogeneration Choice
Important Technical Parameters for Cogeneration

FACTORS INFLUENCING COGENERATION CHOICE

The selection and operating scheme of a cogeneration system is very much site-specific and depends on several factors, as described below:

Base electrical load matching :

In this configuration, the cogeneration plant is sized to meet the minimum electricity demand of the site based on the historical demand curve. The rest of the needed power is purchased from the utility grid. The thermal energy requirement of the site could be met by the cogeneration system alone or by additional boilers. If the thermal energy generated with the base electrical load exceeds the plant's demand and if the situation permits, excess thermal energy can be exported to neighbouring customers.

FACTORS INFLUENCING COGENERATION CHOICE

Base Thermal Load Matching :

Here, the cogeneration system is sized to supply the minimum thermal energy requirement of the site. Stand-by boilers or burners are operated during periods when the demand for heat is higher. The prime mover installed operates at full load at all times. If the electricity demand of the site exceeds that which can be provided by the prime mover, then the remaining amount can be purchased from the grid. Likewise, if local laws permit, the excess electricity can be sold to the power utility.

FACTORS INFLUENCING COGENERATION CHOICE

Electrical Load Matching :

In this operating scheme, the facility is totally independent of the power utility grid. All the power requirements of the site, including the reserves needed during scheduled and unsched- uled maintenance, are to be taken into account while sizing the system. This is also referred to as a "stand-alone" system. If the thermal energy demand of the site is higher than that generated by the cogeneration system, auxiliary boilers are used. On the other hand, when the thermal energy demand is low, some thermal energy is wasted. If there is a possibility, excess thermal energy can be exported to neighbouring facilities.

FACTORS INFLUENCING COGENERATION CHOICE

Thermal Load Matching :

The cogeneration system is designed to meet the thermal energy requirement of the site at any time. The prime movers are operated following the thermal demand. During the period when the electricity demand exceeds the generation capacity, the deficit can be compensated by power purchased from the grid. Similarly, if the local legislation permits, electricity produced in excess at any time may be sold to the utility.

IMPORTANT TECHNICAL PARAMETERS FOR COGENERATION

While selecting cogeneration systems, one should consider some important technical parameters that assist in defining the type and operating scheme of different alternative cogeneration systems to be selected.

Heat-to-Power Ratio : Heat-to-power ratio is one of the most important technical parameters influencing the selection of the type of cogeneration system. The heat-to-power ratio of a facility should match with the characteristics of the cogeneration system to be installed.

It is defined as the ratio of thermal energy to electricity required by the energy consuming facility. Though it can be expressed in different units such as Btu/kWh, kCal/kWh, lb./hr/kW, etc., here it is presented on the basis of the same energy unit (kW).

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Basic heat-to-power ratios of the different cogeneration systems are shown in Table 7.2 along with some technical parameters. The steam turbine cogeneration system can offer a large range of heat-to-power ratios.

TABLE 7.2 HEAT-TO-POWER RATIOS AND OTHER PARAMETERS OF COGENERATION SYSTEMS

Cogeneration System	Heat-to-power ratio (kW_th/kW_e)	Power output (as percent of fuel input)	Overall efficiency per cent
Back-pressure steam turbine	4.0-14.3	14-28	84-92
Extraction-condensing steam turbine	2.0-10.0	22-40	60-80
Gas turbine	1.3-2.0	24-35	70-85
Combined cycle	1.0-1.7	34-40	69-83
Reciprocating engine	1.1-2.5	33-53	75-85

TABLE 7.3 TYPICAL HEAT: POWER RATIOS FOR CERTAIN ENERGY INTENSIVE INDUSTRIES

Industry	Minimum	Maximum	Average
Breweries	1.1	4.5	3.1
Pharmaceuticals	1.5	2.5	2.0
Fertilizer	0.8	3.0	2.0
Food	0.8	2.5	1.2
Paper	1.5	2.5	1.9

Cogeneration uses a single process to generate both electricity and usable heat or cooling. The proportions of heat and power needed (heat: power ratio) vary from site to site, so the type of plant must be selected carefully and appropriate operating schemes must be established to match demands as closely as possible.

The plant may therefore be set up to supply part or all of the site heat and electricity loads, or an excess of either may be exported if a suitable customer is available. The following Table 7.3 shows typical heat: power ratios for certain energy intensive industries:

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Cogeneration is likely to be most attractive under the following circumstances:

- ☑ The demand for both steam and power is balanced i.e. consistent with the range of steam: power output ratios that can be obtained from a suitable cogeneration plant.
- ☑ A single plant or group of plants has sufficient demand for steam and power to permit economies of scale to be achieved.
- ☑ Peaks and troughs in demand can be managed or, in the case of electricity, adequate backup supplies can be obtained from the utility company.

The ratio of heat to power required by a site may vary during different times of the day and seasons of the year. Importing power from the grid can make up a shortfall in electrical output from the cogeneration unit and firing standby boilers can satisfy additional heat demand.Many large cogeneration units utilize supplementary or boost firing of the exhaust gases in order to modify the heat: power ratio of the system to match site loads.

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Quality of Thermal Energy Needed :

The quality of thermal energy required (temperature and pressure) also determines the type of cogeneration system. For a sugar mill needing thermal energy at about 120°C, a topping cycle cogeneration system can meet the heat demand. On the other hand, for a cement plant requiring thermal energy at about 1450°C, a bottoming cycle cogeneration system can meet both high quality thermal energy and electricity demands of the plant.

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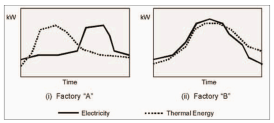

Figure 7.7 Different Heat and Power Demand Patterns in two Factories

Load Patterns :

The heat and power demand patterns of the user affect the selection (type and size) of the cogeneration system. For instance, the load patterns of two energy consuming facilities shown in Figure 7.7 would lead to two different sizes, possibly types also, of cogeneration systems.

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Fuels Available :

Depending on the availability of fuels, some potential cogeneration systems may have to be rejected. The availability of cheap fuels or waste products that can be used as fuels at a site is one of the major factors in the technical consideration because it determines the competitive- ness of the cogeneration system.

A rice mill needs mechanical power for milling and heat for paddy drying. If a cogeneration system were considered, the steam turbine system would be the first priority because it can use the rice husk as the fuel, which is available as waste product from the mill.

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System Reliability :

Some energy consuming facilities require very reliable power and/or heat; for instance, a pulp and paper industry cannot operate with a prolonged unavailability of process steam. In such instances, the cogeneration system to be installed must be modular, i.e. it should consist of more than one unit so that shut down of a specific unit cannot seriously affect the energy supply.

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Grid Dependent System Versus Independent System :

A grid-dependent system has access to the grid to buy or sell electricity. The grid-independent system is also known as a “stand-alone” system that meets all the energy demands of the site. It is obvious that for the same energy consuming facility, the technical configuration of the cogeneration system designed as a grid dependent system would be different from that of a stand-alone system.

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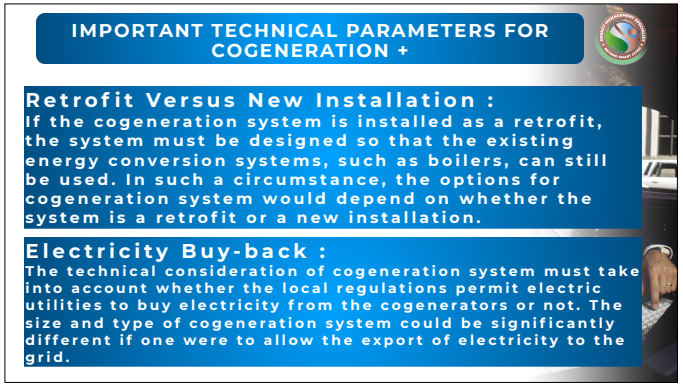

Retrofit Versus New Installation :

If the cogeneration system is installed as a retrofit, the system must be designed so that the existing energy conversion systems, such as boilers, can still be used. In such a circumstance, the options for cogeneration system would depend on whether the system is a retrofit or a new installation.

Electricity Buy-back :

The technical consideration of cogeneration system must take into account whether the local regulations permit electric utilities to buy electricity from the cogenerators or not. The size and type of cogeneration system could be significantly different if one were to allow the export of electricity to the grid.

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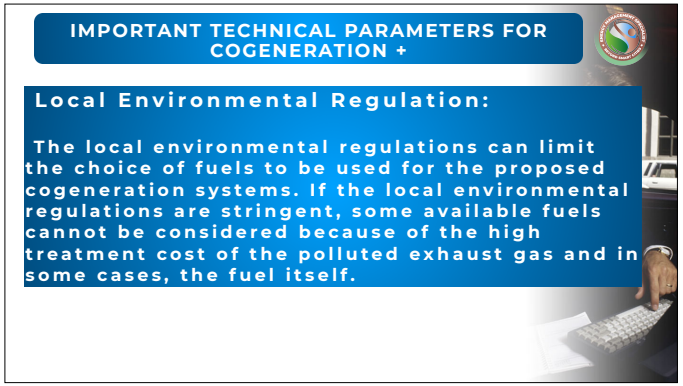

Local Environmental Regulation:

The local environmental regulations can limit the choice of fuels to be used for the proposed cogeneration systems. If the local environmental regulations are stringent, some available fuels cannot be considered because of the high treatment cost of the polluted exhaust gas and in some cases, the fuel itself.

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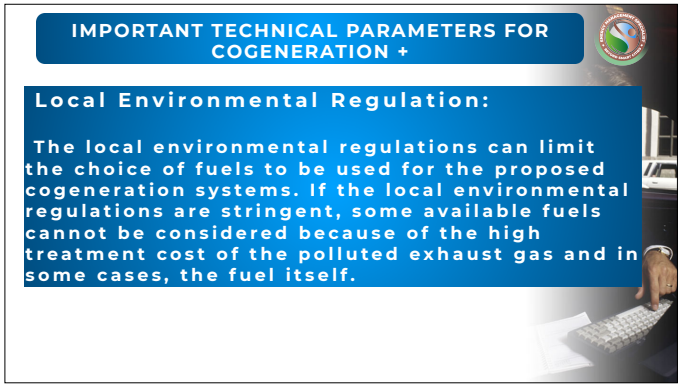

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