

POTENTIAL FOR COGENERATION IN SRI LANKA

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Cogeneration of Energy implies the simultaneous generation of power and heat or thermal Energy from the same fuel source or some variant. The power generated can either be mechanical power, shaft power or electrical Energy while heat produced can be either in the form of steam or hot water. In cogeneration, the equipment or facility should generate power and steam in the same operation. It does not necessarily mean the generation of power and heat within same industrial facility.

Cogeneration is not a new concept. It has been practiced in the process industry from its inception. All chemical process industries, pulp and paper industries and many allied industries practiced cogeneration for well over a half a century- it was efficient to produce steam/hot water and electric power together than thermal Energy alone. This was the practice for years and its popularity decreased after world war II due to low fuel costs which made utility generated power or power generated by large power generating authorities more attractive even though it was inefficient at times.

After the first oil crisis in 1974, when price of oil more than trebled, cogeneration once again grew into a more complex business and ever since then, it has been growing the world over and still has the potential for further dramatic growth.

Cogeneration is not a new technology although it is hastening the application of new technologies. It involves the engineering skills that combine existing hardware into power systems that are economically matched to the particular thermal and electric demands of a given site and the available fuels.

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In early days, cogeneration was economical in only a few industries because many such systems produced more electric power than that could be used internally and the excess could not be sold at attractive rates.

ANALYSIS OF SYSTEMS

When looking at the potential that exists in a country or in an establishment, it is first necessary to analyse the industrial systems separately and collectively. Therefore, Energy load analysis is the first step. Before cogeneration system can be evaluated, the system designer should know the site electric power and heat or steam requirements. With this data, an economic model has to be developed that will compare the various systems and determine revenue streams. Often computer based analysis make the analysis easier and more useful because changes to the system and various equipment options can be accommodated with little effort.

The analysis can begin with finding out how often the plant operates at a particular demand level. The average, maximum and minimum electricity demands have to be determined for each level of steam flow. This exercise can generally be carried out for a fixed steam flow and increments, and for fixed electricity demand increments. The analysis may indicate that the steam flow is the controlling variable. The analysis will evaluate and determine the following:-

- a) The minimum net electric power generation at no process steam flow.
- b) Turbine design point, for both electric power and process steam flow.
- c) Minimum limit on turbine extraction for process steam.

This data is then used by prospective turbine and boiler suppliers to develop the steam cycles and size equipment. It is also

necessary to evaluate the capacity factor during initial evaluation of a cogeneration system. It is the total Energy delivered by the system for a year divided by the Energy deliverable at the design point for 8760 hours/year.

The potential of a site for cogeneration depends on the demand for heat and power at the site. The greater the potential for use of heat at a site, greater is the potential to generate substantial quantities of power.

Steam is a good heating medium and it could be easily transported within a site or within an industrial complex and used at various locations where heat is required. Saturated steam is efficient as a source of heat in the range of 100-200 °C and is widely used in industry in preference to direct heating at the point of application. Generating steam at a central point and transporting to the point of application is generally more efficient than the use of fuel burning equipment at various locations within the same site. Therefore, if the steam demand at a site could be increased then the potential for cogeneration could be very high. In this context, for maximum efficiency, one should look at the ratio of work to heat. As the work to heat ratio increases, the overall efficiency decreases.

COSTING OF GENERATED STEAM AND ELECTRICITY

The economic exploitation of cogeneration potential depends on the methodology adopted for costing of generated steam and electricity. There are two methods- one is the Energy based costing while the other is availability based costing of steam and electricity.

The cost of the product of an Energy-converter or process equals the total expenditure made to obtain it, namely fuel expenses plus the capital and other expenses. In general, the cost equation is written as

$$P_0 C_0 = P_i C_i + Z$$

where P_i , P_0 are the input and output of the interested quantity for a unit time respectively, while C_i and C_0 are unit cost of interested input and output quantity. Z is the

sum of capital investment and other expenses.

When a plant has more than one product such as heat and power, as in a cogeneration system, the above equation cannot be solved for the unique unit cost of the several products. The equation becomes:-

$$C_{sh} P_{sh} + C_{LP} P_{LP} = C_{HP} P_{HP} + 2r$$

where,

sh=shaft power, LP=low pressure, HP=High Press

In solving the equation there are two possible solutions as suggested by KOTUS (1985) as follows:-

- a) Equality method - In this method, the same priority is attributed to both shaft power and heat, so that unit cost of shaft power is set equal to the unit cost of low pressure steam.
- b) Extraction method - If the purpose of steam turbine considered is to generate only shaft work, the whole cost of turbine and the inefficiency occurring in it are charged against it so that the unit cost of low pressure steam is equal to the unit cost of high pressure steam.

Based on Energy, the specific cost of LP steam generated from equality method is slightly higher than HP steam due to sum of turbine and HP steam costs being charged to it. This is not realistic as no one will buy LP steam at a price greater than HP steam. However, this is compensated by the low cost of electricity.

Care must be taken where Energy based costing is used with equality method to price electricity for sale to outside parties. With the availability based costing, which is more realistic, the calculated specific LP steam cost is notably lower than HP steam which corresponds to its reality and electricity costs are much greater than under Energy based costing. Hence, the availability based costing with the equality method is suitable for cogeneration systems that has the same priority of products. It is more realistic than Energy based costing for cogeneration systems.

So when the potential for cogeneration is evaluated, the costing basis must be realistic and the availability based costing with the equality method should be used.

AVAILABLE POTENTIAL

Potential in process industry

The potential that exists in the country for cogeneration has not been fully exploited. Traditionally, the existing cogeneration potential has been only exploited by some of the process industries. As far as I am aware, the potential has been exploited only in the sugar processing industry and the petroleum refinery. Such a facility was also installed at the fertilizer manufacturing plant which is not in operation due to the discontinuation of the fertilizer manufacturing industry. A cogeneration facility was also installed at the National Paper Mills Corporation's plant at Veyangoda which I understand is non-functional now. The advent of cheap hydro power in the 1960's and the lack of skilled craftsmen due to the exodus to the Middle East may be some of the causes for abandoning of such facilities.

Table 1 gives a list of some of the larger process industries where there is a demand for both steam and power, where there is great potential for cogeneration. Of them, the 4 sugar factories, the two paper factories at Valachenai and Embilipitiya and textile processing plants at Veyangoda, Thulhiriya and Pugoda should be considered as the most attractive for cogeneration. These institutions presently use both steam and power in substantial quantities. Although no detailed analysis have been carried out, they are typical industries the world over where cogeneration systems have been economically and successfully operated. Another industry where there is potential is rubber processing and of them, Sri Lanka Tyre Corporation should be the first target, followed by the other private sector rubber processing industries.

Potential in commercial and residential sectors

There also exists a potential for cogeneration in the commercial sector. In recent years both in the US and in Western Europe, there has been much development in the commercial and residential sector.

Primarily large buildings, hotels and other establishments need electricity for lighting, heating and hot water supply. Air conditioning is provided using chilled water systems where cooling is obtained by compression and liquefaction using electrical Energy as the power source. With the increase in use of small units based on absorption cycles using ammonia and water, additional thermal loads have been created and thereby shifting some of the electrical load to the thermal load. With the right combination of heat and power, it will be possible to install cogeneration facilities in such institutions. With the present cost of electricity, there is a much greater incentive, especially for the large hotels, to analyse their systems and become potential candidates for the installation of cogeneration systems. Large hospitals like the General Hospital, Sri Jayewardene Pura, Kandy and Peradeniya are also potential candidates. (See table 2 for consumption details).

INDUSTRIAL ESTATES

Adjacent facilities

Cogeneration needs not be limited to a single establishment between two adjacent sites or a number of different sites in the same locality. In one site, there will be greater demand for electricity while there is no demand for heat or steam while in the adjacent site there will be a much higher demand for heat or steam than electricity. Therefore, the site that needs the power predominantly could install a cogeneration facility and sell the steam to the adjoining facility that needs steam. This has been practiced in many countries. Even in Sri Lanka, the refinery generates power and steam from its cogeneration facility and sells steam to the Nylon 6 plant established in the adjoining compound. The decision to establish the Nylon 6 plant adjacent to the refinery was purely based on this consideration. The Nylon 6 plant does not use any raw material or by-products from the refinery for producing Nylon 6 yarn.

There is a great potential for this type of development in the Ratmalana industrial zone, Ekala industrial zone and in a number of medium scale industries in and around the country.

Trade Zones

The other areas where there is a great potential are the Free Trade Zones at Katunayake and Biyagama. These zones have a vast potential for cogeneration. They are high users of electricity and use steam to varying extents in the different factories and establishments within the zone. As there is a central authority controlling such zones, the potential is there for the central authority to cogenerate electricity and steam for use in the facility.

In addition to the economic advantage inherent in cogeneration, additional advantage could be obtained from economies associated with scale of the cogeneration facility. **Another advantage that these facilities would have is that any environmental pollution abatement facilities could be centrally established much cheaply.** Stack gas treatment or dispersion of flue gases using high stack could be better and more economically handled by a central facility.

It may be prudent to think of such a facility for the zone at Galle that is being planned.

PROVIDING RURAL ENERGY

In Fiji, they have installed a cogeneration plant providing heat for copra drying and electricity for village lighting. This has been operated successfully since 1987. The main system components in these are a wood fired boiler, a 10 kW steam generator, a 3 phase alternator and a fan cooled condenser providing hot air to the crop drying chamber. In this set up, 47 village houses and a village hall are provided with electricity. The plant is designed to run 4-8 hours each evening. Maintenance is simple and the plant is operated by the villagers themselves.

The cost of cogeneration system with the village electrification cost has been US \$ 42,000. Similar units could be established in our plantation sector and the large paddy milling plants where paddy husk is available as a fuel.

COGENERATION AT NON ADJACENT SITES

Cogeneration potential can be further exploited by two different sites that are not adjacent to each other. Consider a case where the same organisation or institution have two sites where one needs power and the other needs more thermal Energy or steam. The site that needs the steam could cogenerate both electricity and steam and the steam is used at the generation site where there is a large demand for it and wheel the electricity via the public grid to the site that needs the electricity. This is being practiced in the United States in some facilities.

COGENERATION AND SELLING POWER TO THE NATIONAL GRID

At locations where demand for steam is high, cogeneration could be practiced by generating the required steam at site using high pressure boilers and back pressure turbines. The excess power generated is then sold to the national grid. In the US, legislation makes it compulsory for the utilities in the various states to purchase the generated power at the costs the utility would have incurred if it were building a new plant to meet the demand, ie the avoided cost.

COGENERATION FOR RELIABILITY

There can also be a potential for cogeneration to obtain reliability. If the national grid supply is not 100% reliable, then there could be production losses and detrimental effects on the process. In such instances, it may become economical to operate a cogeneration plant and ensure that the necessary reliability is provided from the in-house cogeneration facility.

To establish the true cogeneration potential in the country, the Ministry of Power and Energy should initiate a more detailed study and the information that is provided here can only serve as a guide to initiate such a study.

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He joined the Ceylon Petroleum Corporation in 1969 and held positions of the Head of Operations and Operations Manager of the Refinery until he was appointed the Refinery Manager in 1975. He was a participant in the Fuel Conservation Training Course held in New Delhi in 1975 sponsored by the Asian Productivity Organisation, Japan and the Energy Management Training Programme sponsored by the State University of New York and the Brookhaven National Laboratories, New York in 1979.

Mr. Chandrasekera in a founder member of SLEMA and held the post of President in 1987/88.

	Electricity (GWh)		Diesel (MT)		Furnace oil (MT)		Power/heat ratio	
	1988	1989	1988	1989	1988	1989	1988	1989
<u>Sugar</u>								
Hingurana	1.55	1.78	498	495	252	2101	0.17	0.06
Kantale	0.74	0.97	379	390	322	286	0.09	0.12
Sevanagala	2.40	2.32	791	704	3930	2237	0.04	0.06
<u>Tyre</u>								
Tyre Corp.	11.31	11.53			4081	3405	0.24	0.30
<u>Paper</u>								
Valachchenai	15.35	12.37	5	13	5404	3511	0.25	0.31
Embilipitiya	17.05	11.85	143	138	4269	3224	0.34	0.31
<u>Processes</u>								
Liver Bros	8.12	8.39			5451	5554	0.13	0.13
BCC	0.95	1.55			810	952	0.10	0.11
<u>F & B</u>								
McCallum	0.47	0.48	154	143			0.25	0.27
Nuwara Eliya	0.62	0.53			440	409	0.12	0.11
Cold Stores	3.27	3.95		441	531	599	0.54	0.32
Pure Beverag	1.29	1.17		248	251	229	0.45	0.21
<u>Textile</u>								
Veyangoda	11.45	11.55			3327	2796	0.30	0.36
Thulhiriya	13.94	13.86			1588	729*	0.77	1.67
Pugoda	15.93	14.29			5104	4621	0.27	0.27

* Part of steam generated using fuelwood

Table 1- Energy consumption in some Sri Lankan process industries

	Electricity (GWh)		Diesel (MT)		Furnace oil (MT)		Power/heat ratio	
	1988	1989	1988	1989	1988	1989	1988	1989
<u>Hotels</u>								
Ramada	6.18	6.16			142	141	3.81	3.83
Oberoi	12.71	10.60			207	557	1.58	1.67
InterContin.	5.35	5.05			210	229	2.23	1.94
Hilton	8.92	8.77	254	270			2.88	2.66
Galadhari	8.48	8.23	833	613			0.83	1.11
Taj Samudra	7.86	7.64			482	556	1.43	1.21
<u>Hospitals</u>								
SJP	2.67	2.63			104	103	2.26	2.24
General	6.67	5.91	na	na	na	na		
Peradeniya	na	na	83	82				

Table 2- Energy consumption in some Sri Lankan commercial and residential institutions.