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CANE COGEN INDIA

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Packaged Steam Turbine Cogeneration for Process Industries

by Mr. Vijaykumar Dumbali, CEO & Managing Director, Biogreen Energy Systems (P) Limited

Please fill in and send us the feedback form enclosed. Sugar mills are requested to also fill in their technical details. Thank you.

Introduction

Steam Turbines are one of the oldest machines used to convert heat energy into useful mechanical or electrical energy. At the same time cogeneration is also an age-old technique used by large-scale steam users such as the sugar industry. Simultaneous generation of two forms of energy (i.e. steam and power) is generally known as Cogeneration or Combined Heat and Power (CHP). This paper elaborates how Steam Turbine based Cogeneration can be successfully applied to small and medium scale process industries.

What is Cogeneration?

Cogeneration is simultaneous generation of two forms of energy – Electrical Power and Steam from a primary fuel source. In case of steam turbine based cogeneration, steam from the boiler is first fed to a steam turbine generating electrical power, and then the same steam is fed to a process plant at required pressure. It is explained schematically in Figure 1 (see page 2).

CONTENTS

Why Cogenerate?

Centralized Thermal Power Plants convert just about 33% of the energy available into useful electrical energy. This is because nearly 67% of the primary energy is lost to the atmosphere in the form of heat, thus adding to global warming. It also leads to an increase in the cost of electricity generated (Figure 2).

Process industries generate steam for their various processes and buy electrical power from the utility to meet their power demand. On buying power from a utility, we also pay for the 67% energy lost to the atmosphere. This is also not without incurring huge Transmission and Distribution (T&D) losses. However a cogeneration system can enhance the total system efficiency to as high as 85%. Such systems usually generate power virtually free of cost since the steam is used twice i.e. first to generate power and then to meet the thermal demand of the process plant.

How to Cogenerate successfully

For successful implementation of a cogeneration system, a detailed analysis and proper conceptualization of the Steam Turbine Generating Set is very essential. An expert needs to do this job. In addition, several issues need to be sorted out before a right system is put into place.

Cause & Effect

One cannot always generate the amount of power intended from the cogeneration route. It is very

Myths and Facts

Myth

I want a cogeneration system of 750 kW to meet my entire power demand of the plant

You cannot, always!

Fact

I have steam at 17.5 kg/cm² (g) and I use 5 tonnes per hour of steam at 3.0 kg/cm² (g) in my process plant. How much power can I generate?

YES – Right Directon

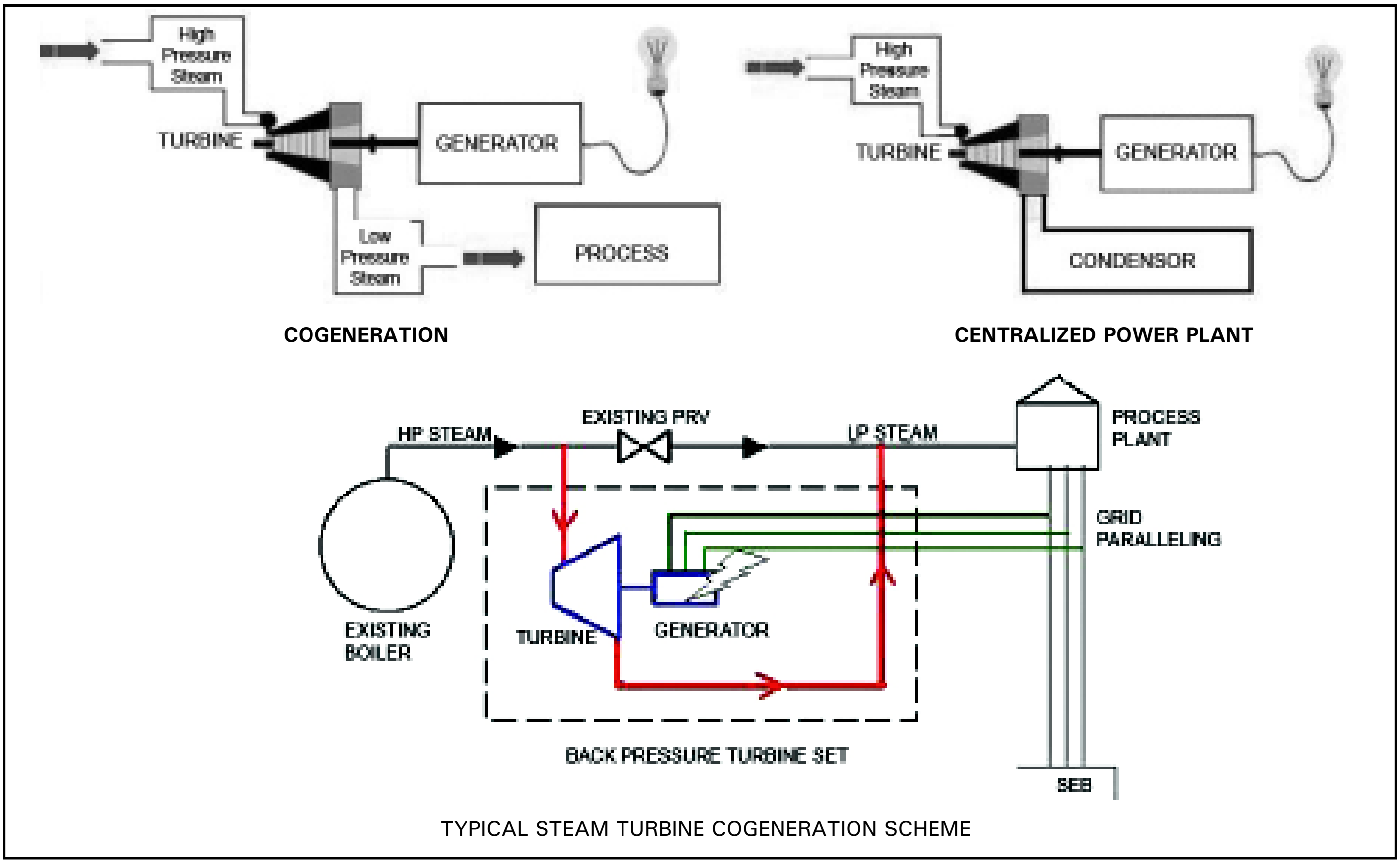

Figure - 1

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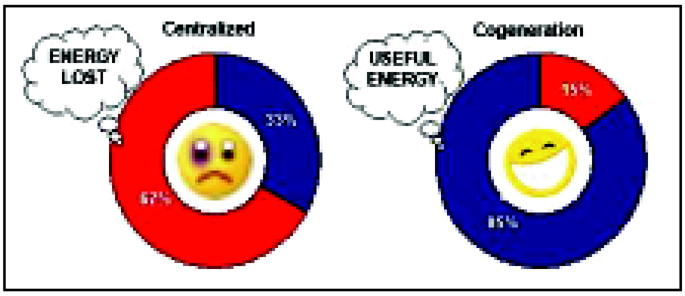

Figure - 2

important to understand the "Cause & Effect" for any successful cogeneration. "Amount of Steam" is the "Cause" and the "Power Generated" is the "Effect". Power generated from cogeneration is however "Incidental Power", which is generated incidentally while meeting the process plant's steam demand. Therefore, one cannot always optimize the power generation by using higher pressure steam boilers. However, this is possible only up to a certain point for small to medium needs.

Any variation in steam demand will vary the amount of power generated. As such, the power demand of a process plant may not vary linearly with the steam demand. Also, large induction motors demand higher currents while starting. The turbine, if trying to meet the entire demand, may trip due to low frequency in trying to meet the sudden demand to start the motors. Thus, it is always advisable to look at meeting the entire power demand only when it is possible and in situations where grid power is not available.

Single Stage / Multi-stage and Turbine Efficiency

Turbine efficiency depends on various factors; one of these is whether the turbine is multi-stage or a single stage. Whether a single stage machine is suitable or a multi-stage machine is required depends on the models produced by the turbine manufacturer. It is also in relation to the enthalpy that needs to be dropped in the turbine (i.e. difference in inlet and outlet). It is not always true that a multi-stage turbine is better; it is also advisable to talk to a turbine manufacturer to understand how much power can be generated from a set of steam parameters – leaving the choice of multi-stage or single stage to them.

Turbine Speed

Usually higher turbine speeds add to the efficiency of the turbine, through lowering certain turbine losses. However, high speed turbines also come with certain disadvantages. If the operating speed is beyond the first critical speed of the turbine, the machine is sure to experience violent vibrations every time it crosses the first critical speed during every startup. Hence a turbine which operates at less than its first critical speed is always preferred. High speed machines can tolerate lesser misalignment of rotating components than low speed machines. Generally, turbines with operating speeds up to about 6,000 rpm provide good efficiencies as well as longer trouble free operations. It is very important to understand that once installed, the turbine becomes very important and an integral part of the process industry. Keeping this in mind, it is preferable to install a medium speed turbine with good efficiency. It can then operate trouble-free for a longer duration than a high speed and more efficient turbine which poses a possible risk of breakdown in the absence of expert turbine operators. If a high-speed turbine becomes inevitable, then it must have an independent redundant mechanical over speed trip and a vibration monitoring system as well.

Power Utilization

The next most important aspect that needs to be considered is the method in which the power generated is to be used. There are essentially two ways, i.e., Stand-alone Operation and Grid Synchronized Operation (see Table below).

Induction Generator or Alternator?

Steam turbines can be configured either with an Induction generator or an alternator for power generation. In principle, induction generators are “reverse” induction motors. When an induction motor is rotated using external mechanical energy, it generates power. However, induction generators lower the plant’s overall power factor. Induction generator based systems have the advantage that they synchronize with the plant grid very easily without any external synchronization system in place. However, they come with a host of other disadvantages such as, they cannot be operated in the absence of grid and with poor part load

Parameters	Stand-alone	Grid Synchronized
Steam and Power Demand Variations	Steam flow is a function of electrical load put on the generator. Thus, if process plant’s steam demand reduces below what is flowing through the turbine to meet the load, additional steam is vented off.	Power generated is a function of the steam flowing through the turbine. If process plant’s steam flow varies, the power output also varies but the difference will be drawn from the grid.
Motor Startup Currents	Can not take high startup power demands of comparatively larger motors. The turbine may trip due to under frequency.	Can take high startup power demands since the grid balances the differential.
Power Reliability	If the turbine trips due to any reason, the loads it is catering to will be shut down thus disturbing the manufacturing process	If, the turbine trips due to any reason, the grid is available to supply the additional power, avoiding plant shutdown. When the turbine is back on line, it can be synchronized with the grid again.

efficiencies, whereas alternators have better efficiencies at lower loads as well. However, these require an external synchronizing system to synchronize with the grid. It is always preferable to use an alternator with an external grid synchronizing equipment as compared to the induction generators, unless the steam turbine under consideration is less than 250 kW capacity. Further, the connected load should be very large as compared to the turbine capacity.

Ease of Operation

For an optimum and trouble-free continuous operation, steam turbine demands meticulous and proper operation. Generally, process industries do not engage turbine operators as it adds to their operating costs, sometimes seriously off-setting the money saved by installing the turbine itself! It is therefore recommended that small to medium capacity turbines with PLC based control systems be installed. PLC based control systems do not demand continuous operator attention and thus can be configured to suit individual needs. With PLC based systems, one can also explore the possibility of remote process monitoring system (RPMS). Simply put, the turbine supplier can remotely observe the day-to-day operation of the turbine, take corrective actions and can also plan for the desired preventive maintenance schedules.

Packaged Turbine System

Individual Component Reliability

A turbine generating set comprises several important components besides the turbine itself. It is thus very important to ensure that all the components that make a turbine generating set are reliable and serviceable.

Packaged Systems vs. Site Built Systems

Packaged steam turbine generating sets are completely assembled, pre-piped and factory tested ready to install equipment. Since packaged systems are factory tested, they drastically reduce the on-site installation time.

Control System

Turbine Steam Testing

Most of the turbine manufacturers have a facility for steam testing the turbines before they are dispatched from the factory. It is recommended that the purchaser insists on live steam testing at the turbine manufacturers' factory before the turbine is dispatched. This ensures that the turbine is defect free and also does not pose any problems when it is steamed for the first time at site, during commissioning.

Turbine Safety

One of the most important aspects is safety. It is recommended to have multi-level safety features, besides redundant safety levels, to ensure that the turbine operates safely. One of the important safety measures is to ensure an independent mechanical over speed trip mechanism. This is a trip mechanism that operates independently. In case of any instrumentation failure, one can rest assured that the mechanical trip will take care of the turbine and the operator's safety. It is recommended that turbine makes be chosen that fully adhere to international design codes such as API 611 or NEMA, though this is not mandatory by the statutory agencies. Code compliant turbines can be expected to have better safety and reliability.

Summary

Any process industry using low pressure steam has an opportunity to generate its own power using packaged steam turbine generating sets. However, various important aspects, as discussed in this paper, need to be considered while conceptualizing a suitable system. It is very important to understand that power generated from a cogeneration system is "incidental power" and thus a by-product. One should very carefully approach a scheme where one wants to meet the entire power demand of the process plant using steam turbine. Further, it is very important to design a system which will seamlessly integrate the power generated from a turbine into the plant's electrical grid.

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Evaluation of Biomass Gasification Projects under Clean Development Mechanism in India — Part-II

Effective potential of agricultural residues

Agricultural residues are the most commonly used biomass feedstocks for biomass gasification projects in India. Table 1 presents agricultural residue availability per tonne of grain produced based on the available data on residue to crop ratio. It may be noted that wheat straw is used as cattle feed in rural India. The Paddy straw however, is used as domestic fuel, as cattle feed, in manufacturing straw board, as a raw material for paper and hardboard units and as packing material for glasswares, etc. Similarly, bagasse is mostly used for meeting the thermal energy requirement of sugar mills. Therefore, in this study, these agricultural residues have not been considered for the estimation of the utilization potential of biomass gasification projects within the country.

Availability of agricultural residues as energy feedstock essentially depends upon the total amount of crop produced, residue to crop ratio for the crop, collection efficiency (which also includes storage-related considerations) and amount used in other competing applications. Table-1 presents the potential availability of agricultural residues for energy applications of select crops in different states (Purohit et al., 2006). The effective availability of agricultural residue for energy application is highest in the southern states (Kerala, Andhra Pradesh, Tamil Nadu, etc.) as compared to the northern states (Punjab, Haryana, Uttar Pradesh, Rajasthan, etc.) of the country. The highest production of agricultural residues in the southern states of the country can be attributed to the fact that the production of non-fodder, non-fertilizer agricultural residues is higher in these states as compared to the northern states. The all India annual potential availability of agricultural residues for energy applications has been estimated to be 74 million tonnes on an annual basis.

The specific biomass consumption in the dual-fuel mode of operation of a biomass gasifier based system essentially depends on a number of factors such as type of biomass, its moisture content and calorific value, operating load on the biomass gasifier based system, diesel replacement factor, etc. (Nouni et al., 2007). In this study, specific biomass consumption at rated capacity of biomass gasification project has been considered as 1.1 kg/kWh (Tripathi et al., 1997). With the capacity utilization factor of 25%, the annual potential of biomass gasifier based power project in terms of plant capacity could reach around 31,000 MW if the net available agricultural residue for energy applications is to be diverted in the gasification process. Table 2 presents the estimated potential of biomass gasification projects in different states of India (in MW).

Table-1: Agricultural residue availability (in kg) per tonne of grain produced

Crop	Crop-residue	Residue to crop ratio	Agricultural residue availability (in kg) per tonne of grain produced
Groundnut	Groundnut shell	0.33	330
Wheat	Wheat straw	1.47	1470
Paddy	Rice husk	0.33	330
	Paddy straw	1.53	1530
Sugarcane	Bagasse	0.25	250
Cotton	Cotton stalk	3.00	3000
Arhar	Arhar stalk	1.32	1320
Corn	Corn cobs	0.30	300
	Corn stalks	1.56	1560
Jute	Jute sticks	2.30	2300
Mustard	Mustard stalks	1.85	1850

Mitigation potential of biomass gasification projects

The amount of CO_2 emissions saved by a biomass gasification project would essentially depend upon the amount(s) of fuel(s) saved by its use, which, in turn depends upon the annual useful energy provided by the biomass gasifier based power project. In case of electricity substitution, the gross annual CO_2 emissions reduced can be estimated as a product of annual electricity generation and baseline emission factor. There are five regional grids within the country viz. Northern, Western, Southern, Eastern and North-Eastern and different states are connected to any one of these regional grids (Purohit, 2008). The CO_2 emissions mitigation through biomass gasification projects in India is estimated on the basis of the regional baseline. With respect

Table-2: State-wise annual potential availability of agricultural residues for energy applications in India

State	Agricultural residues (million tonne)									
	Rice husk	Maize cobs	Maize stalks	Arhar stalk	Groundnut shells	Cotton stalk	Jute & Mesta sticks	Mustard stalk	Coconut coir	Total
Andhra Pradesh	2.89	0.33	1.71	0.22	0.51	0.65	0.22	NA	1.67	8.20
Assam	1.01	NA	NA	NA	NA	NA	0.22	0.20	0.21	1.63
Bihar	1.37	0.34	1.74	0.06	NA	NA	0.41	0.14	NA	4.06
Chhattisgarh	0.82	NA	NA	NA	NA	NA	NA	NA	NA	0.82
Goa	NA	NA	NA	NA	NA	NA	NA	NA	0.19	0.19
Gujarat	0.25	0.14	0.74	0.11	0.17	0.45	NA	0.33	NA	2.20
Haryana	0.68	NA	NA	NA	NA	0.54	NA	0.78	NA	1.99
Himachal Pradesh	0.17	NA	NA	NA	NA	NA	NA	NA	NA	0.17
Jammu & Kashmir	NA	0.12	0.63	NA	NA	NA	NA	NA	NA	0.75
Jharkhand	0.41	0.03	0.13	0.03	NA	NA	NA	NA	NA	0.60
Karnataka	0.94	0.48	2.52	0.26	0.23	0.38	NA	NA	2.68	7.50
Kerala	0.19	NA	NA	NA	NA	NA	NA	NA	8.41	8.60
Madhya Pradesh	0.24	0.28	1.43	0.23	0.06	0.09	NA	0.51	NA	2.85
Maharashtra	0.49	0.05	0.26	0.67	0.12	0.70	0.01	NA	0.37	2.68
Meghalaya	NA	NA	NA	NA	NA	NA	0.02	NA	NA	0.02
Orissa	1.16	NA	NA	0.08	0.02	NA	0.04	NA	0.17	1.47
Punjab	2.31	0.11	0.55	NA	NA	0.47	NA	0.10	NA	3.53
Rajasthan	NA	0.23	1.21	NA	0.05	0.32	NA	1.85	NA	3.65
Tamil Nadu	1.82	0.04	0.23	0.06	0.37	0.13	NA	NA	4.83	7.48
Uttar Pradesh	2.91	0.34	1.78	0.50	0.03	NA	NA	1.27	NA	6.84
West Bengal	3.14	0.02	0.11	NA	NA	NA	2.38	0.59	0.51	6.75
Others	0.78	0.11	0.56	0.05	0.03	0.04	0.02	0.18	0.23	1.99
All India	21.60	2.61	13.59	2.28	1.57	3.76	3.32	5.96	19.27	73.97

to CEFe, the range of regional grid average emission factors in India is from 420 gCO_2/kWh in the North-eastern grid to 1050 g CO_2/kWh in the Eastern grid, as per the latest updated baseline data on carbon dioxide emissions from power sector (version 2) by the Central Electricity Authority (CEA) of the Government of India. Table 3 presents the CDM potential of biomass gasification projects in India on the basis of the regional baselines. The gross annual CER potential has been estimated at about 58 MT. Amongst all the states in India, Kerala has the largest annual CO_2 emissions mitigation potential through biomass gasification (i. e. 6.72 million tonnes) followed up by West Bengal (6.42 million tonnes), Andhra Pradesh (6.40 million tonnes), Karnataka (5.86 million tonnes), Tamil Nadu (5.85 million tonnes), Uttar Pradesh (4.96 million tonnes) and so on. An analysis of the crop residue-wise break-up of the CDM potential of biomass gasification indicates that amongst all the agricultural residues considered in this study, rice husk has the highest potential for CO_2 emissions mitigation (17 million tonnes) followed by coconut-coir (15 million tonnes), maize stalks (11 million tonnes) and mustard stalk (4 million tonnes).

Prospects of biomass gasification projects in India

The diffusion of a technology, measured in terms of the cumulative number of adopters, usually conforms to an exponential curve as long as the new technologies manage to become competitive with incumbent technologies (Islam and Haque, 1994). Otherwise, the steep section of the curve would never be reached because technology use falls back to zero at the removal of subsidies (Purohit and Michaelowa, 2007). The exponential growth pattern may be of three types – (i) simple exponential, (ii) modified exponential, and (iii) S-curve. Out of these three growth patterns, the simple exponential pattern is not applicable for dissemination of renewable energy technologies, as it would imply infinite growth (Islam and Meade, 1997). The modified exponential pattern (with a finite upper limit) is more reasonable but such a curve may not match the growth pattern in the initial stage of diffusion (Martino, 2003). Empirical studies have shown that in a variety of situations, the growth of a technology over time may conform to an S-shaped curve, which is a combination of simple and modified exponential curves. The S-shaped curves are characterized by a slow initial growth,

Table-3: Annual CO_2 mitigation potential through biomass gasifier based power projects in India

State	Potential of gasification projects (MW)	Annual electricity generation (TWh)	Region	Baseline (kg CO_2/kWh)	CO_2 mitigation potential (million tonne)
Andhra Pradesh	3403	7.45	Southern	0.86	6.40
Assam	679	1.49	North Eastern	0.42	0.63
Bihar	1685	3.69	Eastern	1.05	3.86
Chhattisgarh	340	0.74	Western	0.81	0.60
Goa	79	0.17	Western	0.81	0.14
Gujarat	913	2.00	Western	0.81	1.62
Haryana	827	1.81	Northern	0.80	1.45
Himachal Pradesh	71	0.16	Northern	0.80	0.12
Jammu & Kashmir	313	0.69	Northern	0.80	0.55
Jharkhand	249	0.55	Eastern	1.05	0.57
Karnataka	3113	6.82	Southern	0.86	5.86
Kerala	3569	7.82	Southern	0.86	6.72
Madhya Pradesh	1181	2.59	Western	0.81	2.10
Maharashtra	1111	2.43	Western	0.81	1.97
Meghalaya	7	0.01	North Eastern	0.42	0.01
Orissa	611	1.34	Eastern	1.05	1.40
Punjab	1466	3.21	Northern	0.80	2.56
Rajasthan	1516	3.32	Northern	0.80	2.65
Tamil Nadu	3106	6.80	Southern	0.86	5.85
Uttar Pradesh	2838	6.22	Northern	0.80	4.96
West Bengal	2800	6.13	Eastern	1.05	6.42
Others	827	1.81	—*	0.85	1.54
All India	30707	67.25			57.98

**All India average emission factor 0.85 kg CO_2/kWh has been used*

followed by rapid growth after a certain take-off point and then again a slow growth towards a finite upper limit to the dissemination (Purohit and Kandpal, 2005). Therefore, in this study, a logistic model is used to estimate the theoretical cumulative capacity of biomass gasification projects at different time periods.

Figure 1 represents the projected time variation of the cumulative capacity of biomass gasification projects, using the logistic model considered in the study. Two cases such as business as usual or standard scenario (SS) and optimistic scenario (OS) are presented. The values of the regression coefficients using a logistic model have been estimated by regression of the time series data for the installation of biomass gasification projects extracted from the annual reports of the MNRE (MNRE, 2008). In the optimistic scenario, it is assumed that in the past, if the diffusion of biomass gasification projects would have been driven by the market forces instead of subsidies, then the cumulative capacity of installation of biomass gasification projects would be three times more than the actual level. The preliminary results indicate that in India, even with highly favourable assumptions, the dissemination of biomass gasification projects is not likely to reach its maximum estimated potential in another 50 years. But all these time periods are not relevant for the CDM, whose current endpoint is 2012. So, it may only be able to live longer if post-2012 negotiations retain an emission target based policy regime. However, CDM could be used as a tool to foster the dissemination of biomass gasification

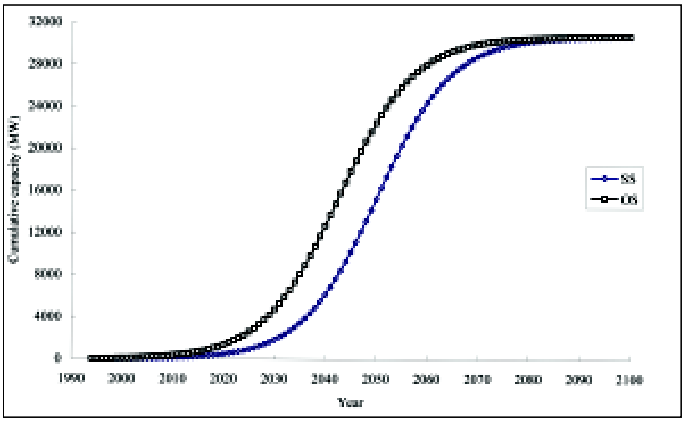

Figure 1: Time variation of cumulative capacity of biomass gasification projects in India using logistic model

projects in the country. It could even accelerate the diffusion process.

Table-4 presents the projected values of the cumulative capacity of biomass power and likely CER generation using the logistic model. It may be noted that with the current trend of dissemination of biomass gasification projects in the country, around 166 MW capacity could be installed up to the end of the first crediting period in the SS scenario, whereas in the OS scenario 478 MW capacity could be installed. Up to the year 2020, more than 1300 MW capacity of biomass gasification projects are expected to be installed, which is expected to generate 3 million CERs.

Table-4: Projected values of the cumulative capacity of biomass gasification projects and associated CERs

Year	Projected values of the cumulative capacity (MW)		Projected values of the annual electricity generation (TWh)		Projected values of the annual CER generation (million CER)	
	SS	OS	SS	OS	SS	OS
2012	166	478	0.36	1.05	0.31	0.89
2016	285	814	0.62	1.78	0.53	1.51
2020	490	1373	1.07	3.01	0.91	2.56

*Baseline 850g CO_2/kWh

Conclusions

A preliminary assessment of CDM potential of biomass gasification projects in India has been made in this study. The results indicate that, there is a vast theoretical potential of CO_2 emissions mitigation by the use of biomass gasification projects in India. A simple framework developed for the estimation of effective potential availability of agricultural residues for energy applications in India indicates that around 74 million tonnes of agricultural residues (whose effective and efficient utilization is critically important), as a biomass feedstock, can be used for energy applications on an annual basis. On the basis of the theoretical estimates presented in this study, the potential of biomass gasification projects could reach 31 GW in terms of plant capacity that can generate more than 67 TWh of electricity annually. The preliminary estimates presented in this study indicate that the annual CER potential of biomass gasification projects in India could theoretically reach 58 million tonnes. Under more realistic assumptions about diffusion of biomass power projects based on past experiences with the government-run programs, annual CER volumes could increase from 0.4 to 1.0 million by 2012 and further get to 3.0 million by 2020. It is here that CDM could help to achieve the maximum utilization potential more rapidly as compared to the current diffusion trend, if supportive policies are introduced.

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Energy Saving in Cutter & Chopper Motors in Sugar Plants

Background

The designers of any electro-mechanical system rarely ponder over the question of energy saving aspects involved in operating the designed system. One such typical example is the cutter and chopper motor used in sugar plants and similar loads in other plants. However it is very important to take into account a designer's view prior to highlighting the energy saving options.

First, let us understand the type of the load that is being envisaged. In this case, the load of cutter/chopper motor is sugar cane. This load needs to be chopped and cut into small pieces by a mechanical device. The torque and speed characteristics experienced by the devices are such that in normal running the torque is well taken care of by an ordinary squirrel cage motor. The immediate question that comes to mind here is - what happens when there is inrush of materials. The torque requirement shoots up to almost 150% of normal running torque. The issue therefore is of generating this extra torque as and when required.

Available Options

There are quite a few options at hand to meet the targeted value. Following is a brief description of each such option:

D.C. Motor: It can develop a torque, up to 250% of its rated torque, for about 2 minutes without any operational problems. However, these are deemed expensive for this type of application and hence ruled out.

A.C. Motor: An ordinary induction motor with a normal starter can never produce a torque more than its rated torque. It can do so only in combination with vector drive, which is very expensive for this application and hence ruled out too.

A.C. Motor: A slip ring motor as we know can develop an extra torque, upto 150% of its rated torque, if proper resistance is introduced into its rotor. This is the most favourable option for designers and is adapted in the given situation.

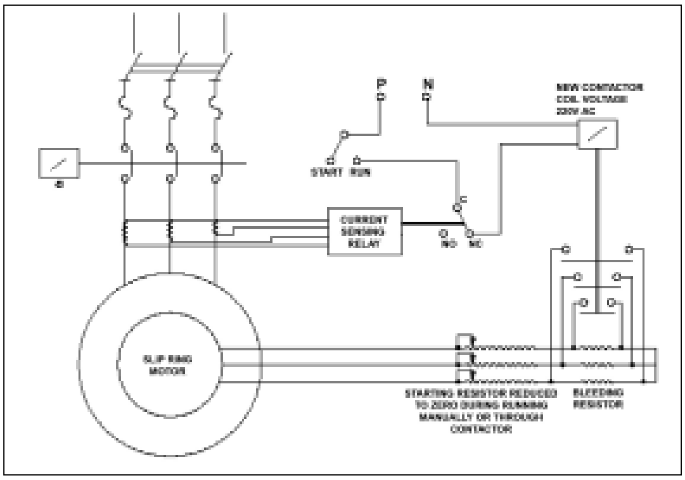
Flywheel

One option that can be thought of is providing a flywheel to take care of the fluctuating load. The flywheel can smoothen out pulsating mechanical load but cannot generate extra torque when needed. Hence, designers always opt for it for achieving this through electrical schemes.

It is interesting to see how the third option, i.e. AC motor, is implemented by the designers and study its implications as far as energy consumption is concerned.

Schematic Outlook

For a better understanding of the situation, let us take a look at the following wiring diagram. There are two resistors introduced into the rotor circuit. One is known as starting resistor and other is called bleeder resistor. Both of them remain in the circuit while starting. Thus, the motor develops required extra starting torque and also limits the starting current to safe levels. As the motor picks up speed, the starting resistor is slowly reduced to zero, either manually or through contactor or shorting strips. As a result of which, only the bleeder resistor remains in the circuit. Thus, the bleeder resistance is invariably left in the circuit.

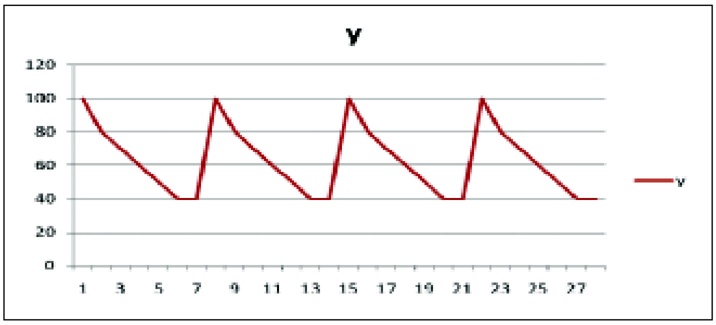


Analyzing the Energy Consumption

It is of absorbing interest to analyze the situation from the point of view of energy consumption as well as output of the equipment. Point specific inference is drawn as under:

- The bleeder resistance consumes almost 10% of the rated power and just converts it into wasted heat This can never be recovered as useful energy. A typical motor which we are talking of, is rated at 337 kW or simply 450 HP. Thus almost 33.7 kW is wasted as heat.
- The speed of the motor is never allowed to reach its rated speed by the bleeder resistor and hence the output of the equipment is reduced by 10%.
- Thus, the arrangement is disadvantageous both from the point of view of productivity as well as from the energy conservation point of view.
- The statistics show that in a typical sugar plant, where the cane is fed by the crane, the load comes in the form of

pulses of say seven to eight minutes. Out of this, in the first one minute it is almost 100% and then it gradually comes down to 40% by the time the next lot is fed by the crane. The graph is as below:



Sometimes due to process variation such as material density change, etc., the load exceeds by more than 100% and demands extra torque. However, such a situation hardly arises once in half an hour. So, for a situation that demands extra torque for one minute in a thirty minute cycle, should the bleeder resistor remain in the circuit for the entire thirty minutes? What are the consequential losses for this extra cushioning in design?

Losses under consideration

Let us consider the following losses on two fronts:

- The energy loss of 33 units per hour. Say Rs.165/-per hour considering Rs.5/-per unit.
- The output loss of 10% throughout the operating cycle because of reduction in speed caused by bleeder resistor.

To overcome this we are suggesting the introduction of the bleeder resistor in the rotor circuit only when it is required. It can be made by sensing the current drawn by the motor. It may happen that current increases in such a way that the motor draws 70% of the full load current. There is also a possibility of further increase that will demand extra torque before jamming occurs. At that stage, the contactor used to bypass the bleeder resistor can be switched off via an electrical circuit. This will bring in extra resistance into the circuit and provide extra torque to overcome the jamming situation. During normal times, the bleeder resistance can be bypassed through the contactor as long as the motor current is less than 70%. This arrangement will save energy which may otherwise get wasted. It will also lead to increased productivity in terms of an enhanced speed of the cutter.

The Circuit Operation

A brief explanation of the working of the circuit will clarify the operating sequence of the circuit. Initially, the start/run switch is kept in start position. This will ensure that the contactor coil does not get any supply and bleeder resistance remains in the circuit. As soon as the starting resistor is bypassed, the switch is kept in the run mode. At that time, if the motor is not drawing more than 70% of full load current then the current sensing relay remains switched off. The contactor coil gets the supply and bleeder resistor is bypassed. This is an energy saving mode. So, whenever the current drawn by the motor exceeds 70% of full load current, the relay picks up. The supply to the contactor coil is withdrawn, the contactor is off and the bleeder resistor is brought into circuit. This creates extra torque to avoid the jamming

Thus, both energy saving as well as avoiding jamming is achieved by this arrangement.

Payback Calculations

It is of an utmost importance to know the period by which one can recover the investment made on a certain type of project like this. The expected investment per motor is detailed below:

- Current Sensing Relay : Rs.10,000/-
- Contactor: Rs. 8,000/-
- Wiring and other miscellaneous work: Rs.10,000/-
- Total Expenses: Rs.28,000/-
- Energy saved per motor 33 units per hour, say Rs.165/- per hour
- Payback period is 169 hours, say ten days

Saving Potential Expected

The approximate number of such plants across India is 600. The range of capacity is 2,500 TCD to 10,000 TCD. A typical 7,200 TCD plant has a cutter motor of 337 kW and Chopper motor of 2 x 335 kW. Thus 10% of this will be a saving of 100 kW per plant. For 600 plants it works out to 60 MW in the sugar industry alone.

Possibilities Galore

There are a number of places where similar material processing and equipments are involved and the same arrangement can be thought of. Just keep your eyes and mind open and you will find them. Below mentioned are just a few examples:

- Lime stone crusher in Cement Plants
- Coal Crushers in Cement Plants, Power Plants, Coal Mining
- Gypsum crushers in Cement Plant and Mining, etc.
- Alumina Crusher in Aluminum Industry

Contd on page 14...

Emerging Trends in MSW based Power Generation Across Asia

Dr P K Balasankari

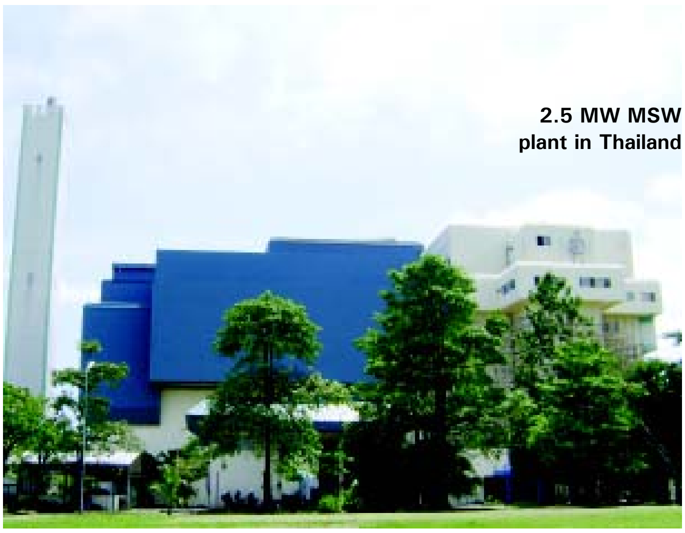
Mr Arul Joe Mathias

Introduction

Municipal solid waste (MSW) comprises domestic waste and commercial waste collected within a certain geographical area. It includes biodegradable waste, recyclable material, inert waste and hazardous waste too. With an increasing rate of MSW generation, many Asian cities are finding it a great menace to deal with. However, with an ever increasing demand of electricity on one hand and the waste disposal issue on the other hand, power generation from MSW offers the best possible solution to both these problems.

Current Practices in Asian Countries

Among Asian countries, only a few countries such as Singapore, Thailand, Korea and Japan have been following advanced MSW management practices for more than two decades. All these countries use MSW incineration plants to get rid of the MSW. Singapore follows the concept of "reduce-reuse-recycle" and the Government of Singapore is quite keen in spreading awareness among the general public about the same. In Asian countries, the MSW management initiative started picking up only after 2000, especially after the development of the CDM concept. Prior to 2000, landfilling was the most common practice to manage MSW. Most of the recent landfill sites however are engineered properly to assist better landfill gas recovery and separation of leachate.



2.5 MW MSW plant in Thailand

The incineration concept is also slowly picking up in Asia. New concepts like segregating biodegradable wastes from MSW and producing biogas in anaerobic digesters are also getting popular. Such types of biogas power plants are already in operation in Singapore, Thailand and India, etc.

Use of advanced technologies such as incineration, RDF combustion, biogas generation and Landfill Gas (LFG) to power for MSW management in Asian cities looks brighter. However, MSW management practices are still far from perfect and need to be improved in these cities.

Landfilling and LFG Recovery

Landfill Gas is a by-product of MSW decomposition. Since the time of maturity of Clean Development Mechanism (CDM), a sizeable number of project developers intensified their search for the landfill sites to set up gas recovery projects. A majority of the sites in Asia turned out to be of open dump type. However, recently engineered landfill sites have been prepared for MSW waste disposal and collection of LFG. In practice, LFG production depends primarily upon the waste composition, weather conditions and most importantly, the landfill management. In order to achieve suitable LFG generation, the amount of waste dumped should be in excess of 1 million tonne. The site chosen for the purpose should essentially have a depth of more than 10 m and preferably without any major fire accident vulnerability as such.The landfill gas can be recovered using a network of perforated gas collection pipes and the gas can be used for power generation. Lately, with the CDM methodology getting stringent these days, the project developers are going in for the closed flare system. In this case, the project emission is minimal as compared to that available from the open flares.

LFG Production

The production of LFG starts in a landfill site within a few months of waste disposal and usually lasts for about 10 years or more depending upon the following few factors:

- composition of waste
- waste availability
- moisture content

Generally, the depth of the landfill gas well is restricted to 80% of the height of the landfill.

The gas is usually pumped out using a blower and the moisture is removed in the moisture trap. Following which, it is cleaned using a SO_2 scrubber before passing it to the engine for electricity production. A landfill is the least cost option for MSW management. However, there is a risk of soil and ground water contamination during rainfall, in the absence of a proper leachate treatment system. In addition, it requires large space which is yet another hindrance to promote landfill projects.

MSW to Biogas

MSW to biogas is one of the new concepts in the management of MSW. Developed countries have taken the lead in treating the bio-degradable MSW through anaerobic digestion. It is a viable option as the sludge from anaerobic digestion can simply be sold as manure. Other major advantage of MSW to biogas is the reduced land requirement. As compared to landfill, the size of MSW biogas plant is very small. This approach involves segregation of biodegradable waste such as vegetable wastes, food wastes, etc., from MSW and then using it in a biogas reactor to produce biogas. In a typical Asian city such as Beijing, Mumbai or Bangkok, etc., organic material accounts for around 80% of the MSW. The net biogas production ranges from 100-120 m per tonne of organic MSW and the compost generation is around 500 kg.

Generally, ferrous and glass removal systems are put in place before the biodegradable waste enters the digester. Separate MSW collection system from vegetable, food and fruit markets may prove helpful in the separation of biodegradable waste for biogas generation. H_2S, CO_2 and moisture have to be removed if the biogas is to be used in engines for power generation. If the biogas generation is expected to fluctuate, then it is better to have a gas holder. Few cities like Singapore, Bangkok and Chennai have installed modern power plants operating with MSW derived biogas.

Role of Incineration

Incineration involves the combustion of Municipal Solid Waste (MSW) without any pre-treatment (also called mass burning). Mass burning has been in practice in the developed countries for more than a 100 years now. As of now, more than 600 mass burning plants are in operation around the world. Volume reduction of MSW for about 90% is possible with incineration plants, thereby resulting in considerable reduction in land required for disposing the 90% MSW. In MSW mass burning system there is no pre-treatment except the removal of visible bulk items. However, some of the wastes such as construction debris, earth, concrete, stones, chemical waste, explosive or highly flammable waste, carbon fibres, insulation materials, Polyvinyl Chloride (PVC) etc., are not suitable for mass burning. It is also advisable to separate the biodegradable wastes from MSW to use in digesters so that the biogas from the digester can be used to generate power using gas engines.

Just a few countries in Asia have a long standing history of proper management of MSW using incineration power plants. As of now, 4 power plants of capacities ranging from 30 MW to 80 MW are in operation (for more than 25 years) in Singapore and one more plant is under commissioning. Also, a 2.5 MW incineration plant is in operation in Phuket, Thailand. For the mass combustion facilities, the minimum calorific value requirement is 7 MJ/kg on an annual average basis. The moisture content and percentage combustible are also important parameters in MSW mass combustion technologies. Even the impact of MSW scavenging on LHV

30 MW MSW plant in Singapore

Large scale MSW plant in Singapore

needs to be taken into account. The investment cost and annual O&M costs for MSW based power plants are much higher than those for the biomass projects. SOx, NOx, dioxin, heavy metals, HCl and air born particulates, fly ash and bottom ash are the pollutants from mass burn power plants. The devices/processes commonly used for effective removal of pollutants include electrostatic precipitators, fabric filters, scrubber & lime injection systems besides activated carbon injection system.

With the use of modern technologies, it is also possible to minimize water pollution, odour and noise problems. In addition, we can recover ferrous metals from the ash so as to generate additional revenue. Japan, China, Korea and Taiwan too have implemented many incineration plants in the recent years. The potential for incineration plants in Asia is high. Amongst all MSW management systems, incineration to power is more popular in Asian cities because it eliminates the need of land requirement so vital for landfilling.

RDF Combustion

Refuse Derived Fuel (RDF) is a method of pre-processing the waste in order to use it as a fuel in boilers. This technology involves various processes to improve physical and chemical properties of solid waste. Basically, RDF systems are used to recover recyclable materials and to separate MSW into combustible and non-combustible fractions. The combustible material is called RDF and can be used in boilers. Typically the volume of waste is reduced between 20 to 30%. In fact RDF has a higher calorific value when compared to that of MSW. Waste sorting includes primary and secondary trommel screens which mechanically separate the dry fraction from the organic one, magnetic and induction-type separators for metals recovery, a glass recovery system and a shredder.

Due to reduction in both the fuel particle size and non-combustible material, RDF fuels are more homogeneous and easier to burn when compared to the MSW feedstock. Emission characteristics of RDF are superior due to less NOx, SOx, CO and CO_2. The advantage of the refuse-derived fuel plant type is the relatively higher energy content of the RDF fuel. Currently, several RDF plants are in various stages of implementation in Asia. In India, an RDF fired MSW plant is in operation for quite a few years. The investment cost of RDF based power plants is higher when compared to that of biomass plants. In addition, implementing such projects often takes more time when compared to the biomass power plant projects.

CDM and MSW Management

Until the year 2000, not much importance was given to the management of MSW in Asia. However, with the advent of

CDM activities, the project developers started paying attention to MSW projects for the benefit of revenue from CER sale. This was done with the primary purpose of making the project more attractive. Interestingly, several CDM project developers got tempted with the active MSW landfill sites in Asian cities. These sites provide an excellent opportunity to recover methane at a low cost and then to produce electricity using gas engines. CER credits can be obtained from two streams: a) from avoidance of methane and b) from electricity generation. Although MSW power plants are eligible under the Clean Development Mechanism, yet there are certain restrictions in selection of technology and usage of MSW. Therefore, the project developer should not neglect these aspects while developing the projects to get CDM specific CER revenue.

Implementing MSW Power Plants

Implementing MSW incineration projects are often more time consuming when compared to biomass power plants. This is because they require very careful preparatory work, else the chances of failure are high. In fact there are several failed MSW plants, which have been sold as scrap. Hence, project developers should pay adequate attention to the necessary preparatory work before implementing these projects. It may also be worthwhile to engage a qualified expert to study all modern concepts and innovative technologies. However, the technology selection should be done carefully.

Plant Economics

As of now, the total investment cost of MSW incineration plants is on the higher side. The higher cost of the MSW projects is mainly due to the requirement of anti-corrosive materials in the construction of the plants, comparatively bigger size of the boiler and complex environmental controls. Additionally, the heterogeneity in the MSW characteristics warrants the flexibility in MSW plant design which increases the cost. The revenue generation from the sale of electricity alone is just not sufficient to make the project commercially attractive. Other parameters such as tipping fee, CDM CER revenue and compost sales are also needed to make the project investment friendly. The total investment cost for landfill sites with power generation and MSW biogas plants is also on the higher side. But, in several situations, CDM revenue plays an important role in the realization of the project.

Future Trend

Renewable Cogen Asia is a company specialized in energy and environment, providing high quality sustainable solutions, throughout the world, in a socially responsible and cost-effective way. The services are customized to the needs of different customer groups, meeting their requirements to the fullest satisfaction.

Our services cover most of Asia, Africa and other regions. We have strategic partners in several Asian countries. Renewable Cogen Asia and its Directors have vast international experience in several countries around the globe and have been involved in more than 50 international projects. For more details visit: www.rcogenasia.com

In future, MSW incineration plants will be the preferred choice of use for the MSW management. This is because of their ability to provide an effective solution to land issues, besides other environmental problems related to landfilling, which is apart from the key advantage of generating electricity.

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...contd from page 10

Energy Saving in Cutter & Chopper...

The Path Forward

Use of special features like those mentioned in this article are bound to result in positive gains, not only for the sugar industry but for other similar industries also. Useful field data available in this manner should be disseminated both for a better understanding as well as for forging any further advancements in these techniques.

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Tariff Order for Bagasse based Cogeneration Plants by TNERC

Background

The state of Tamil Nadu has already attained a leadership position in the area of wind power generation. It is now attempting to provide an equally favourable platform to those interested in producing bagasse based power. The state run electricity regulatory commission issued a comprehensive tariff order for the above mentioned type of power generation on May 6, 2009. It can be readily accessed by all those interested on the following web link: http://tnerc.gov.in/order-06-05-2009.htm We are reproducing here selective portions of this order for a quick understanding.

Bagasse based Cogeneration Scenario

The total installed capacity of power generation in the country is 1,47,458 MW as on 31.01.2009. The contribution of renewable energy sources power to the country's installed capacity is around 13,242 MW *(Source: Central Electricity Authority). The* renewable energy sources power represents 9% of the total installed capacity.

The year wise capacity addition of bagasse based cogeneration plants in Tamil Nadu over the past 10 years is furnished below:

Period	Capacity addition (MW)
Up to 1999-2000	141.60
2000-01	Nil
2001-02	Nil
2002-03	100.50
2003-04	32.00
2004-05	Nil
2005-06	35.00
2006-07	22.00
2007-08	115.00
2008-09 (upto 31-01-09)	20.00
Total	**466.10**

Generation – Demand Gap in Tamil Nadu

The generating capacity connected to TNEB's grid, including the allocation from Central Generating Station, is 10,214.55 MW as on 31.01.2009, comprising 2,970 MW from TNEB's four thermal stations, 516 MW from four gas turbine stations, 2187 MW from 33 hydro stations, 17.55 MW from TNEB's wind farms, 1180 MW from private sector power projects, 214 MW as contribution to the Tamil Nadu grid by sale of electricity from captive generating plants, 2,825 MW as Tamil Nadu's share from central generating stations and 305 MW as external assistance.

Generating capacity from privately owned wind farms is 4119 MW. The installed capacity of cogeneration in sugar mills is 466.10 MW (including 20 MW contributed from co-operative sugar mills) and that of biomass power projects is 147.55 MW.

The average power availability during 2008-09 is around 8,000 MW while the peak demand is around 9500 MW which leaves a deficit of around 1,500 MW. Wind generation contributes about 15% to 20% of the peak demand during wind season and TNEB has no standby capacity to take care of this infirm power fully. Therefore, in case of unexpected meteorological changes, the deficit goes up to 2,000 MW. This deficit is likely to increase in the next few years since the capacity addition is expected to be less than the projected increase in demand. Hence, any addition in power generation will help the State to a great extent to tide over the shortage of power.

Tariff

Tariff for the energy to be procured by the licensee from bagasse based cogeneration power plants has been computed with reference to the determinants listed in the table on page 16. Tariff indicated in the table below is applicable for projects commissioned on or after 19-09-2008. Fixed cost has been tabulated for a period of 20 years. Variable cost has been furnished for 2009-10 and 2010-11. (for more details of the tariff please see TNERC's website)

Fixed Cost

Year of operation (nth year)	Fixed cost per unit (Rs / unit)	Year of operation (nth year)	Fixed cost per unit (Rs / unit)
1st	2.520	11th	1.991
2nd	2.543	12th	1.938
3rd	2.476	13th	1.978
4th	2.410	14th	2.020
5th	2.346	15th	2.064
6th	2.283	16th	2.111
7th	2.221	17th	2.160
8th	2.161	18th	2.211
9th	2.103	19th	2.265
10th	2.046	20th	2.321

Variable Cost

Year	Variable cost per unit (Rs / unit)
2009-10	1.856
2010-11	1.948

Components of Bagasse based Cogeneration Tariff

Parameters	Values
Capital Investment	Rs.4.67 Crore per MW
Plant load factor (PLF)	55%
Debt Equity Ratio	70 : 30
Term of Loan	10 years with one year moratorium period
Interest on Loan	12.00% p.a
Return on Equity (RoE)	19.85%
Life of the Plant	20 years
Depreciation on 85% of capital investment	4.5% p.a on SLM
O & M Charges for Machinery on 85% of Capital investment	4.50% with escalation of 5% from 2nd year
O & M Charges for land and civil works on 15% of Capital investment	0.90% with escalation of 5% from 2nd year
Insurance charges for machinery on 85% of capital investment	0.75% with reduction of 0.50% after one year
Station Heat Rate	3840 kcal per kwh
Calorific value of fuel	2300 kcal per kg
Specific fuel consumption	1.67 kg per kwh
Fuel Cost	Rs.1000 per MT
Working Capital	Fuel stock - one month, O & M - one month and Receivables -one month
Interest on working capital	12.00% p.a
Auxiliary consumption	10%

Source: *http://tnerc.tn.nic.in/orders/Tariff%20Order%202009/CO%20GEN% 20ORDER%206-5.pdf*