BSES Kerala Power Ltd.

165 MW Combined Cycle Power Plant

Plant location:

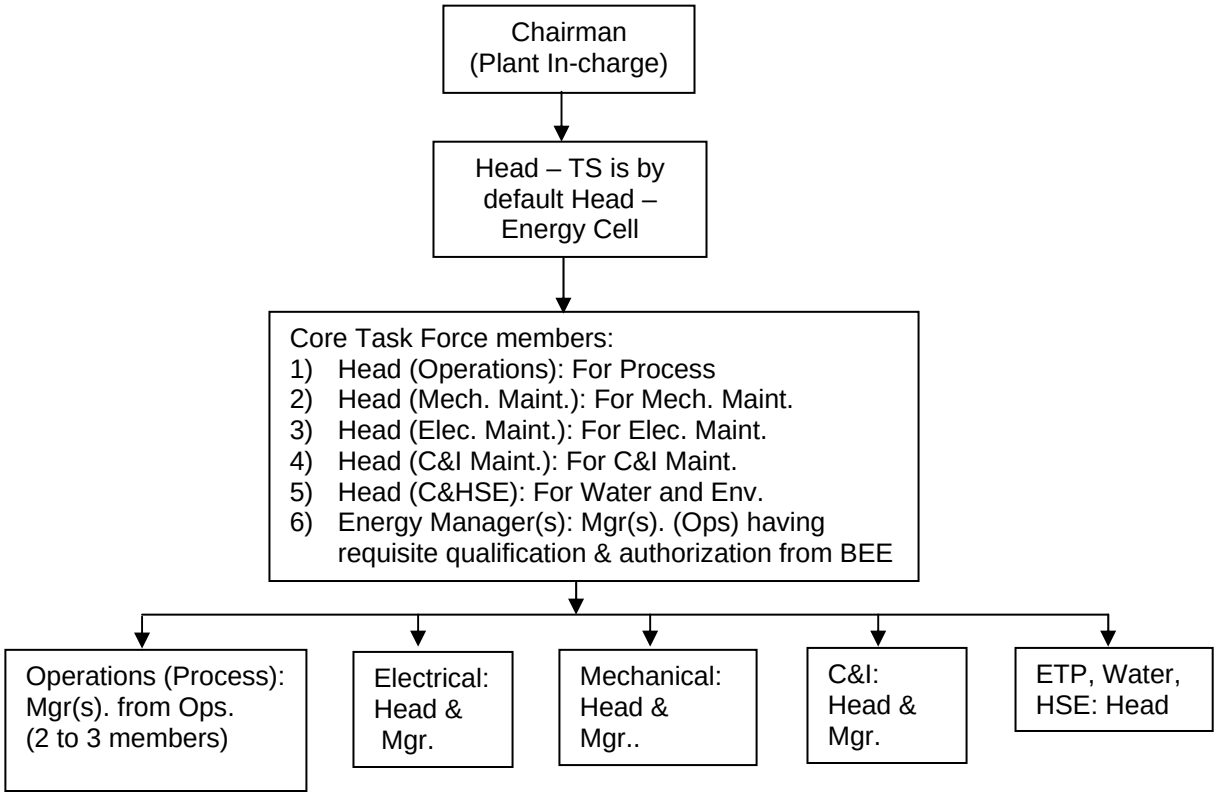
BSES Kerala Power Ltd.
Udyogamandal PO
Kochi 683 501
Kerala, INDIA

BSES KERALA POWER LTD :– MODEL OF 165MW POWER PLANT

BSES Kerala Power Limited

The Energy Management Cell Structure

Energy Management Cell for BKPL has been constituted which is having following structure:



Roles and Responsibilities of the Energy Management Cell:

- Carrying out regular Energy Audits and other associated activities on Energy conservation as per Energy Act2001
- Ensure procurement of suitable monitoring instruments, proper functioning and calibration of instruments required to assess level of energy consumption accurately
- Regular performance assessment of major equipments, Actions to improve monitoring and process control with a view to reduce auxiliary energy consumption; identify the losses and initiate mitigative actions
- Benchmark BKPL performance with the best in the industry and make assessment and action plans for the improvement
- Identifying and implementing Energy conservation measures by preparing annual activity plan and present to management concerning techno-commercially attractive investments
- Arrange for expert consultants, if required, for certain projects for which enhanced level of technical expertise is required, to study the viability/feasibility and/or implementation of the project(s), if found techno-commercially attractive
- Prepare information material and conduct training to staff, develop and manage training programmes for energy efficiency at all levels
- Develop integrated system of energy efficiency and environmental up gradation
- Encourage communication and sharing of ideas between departments and other organizations

- To evaluate the present operating procedures and parameters and develop various ways and means to achieve better efficiency through energy conservation measures as well as better operating procedures
- Conduct regular Meetings, Technical sessions, Brain storming sessions, Collecting and Developing of ideas in Energy conservation Methods which can be implemented
- Maintaining proper documentation of all activities conducted by Energy Cell
- Preparing reports for statutory authorities such as CEA, BEE on plant energy and fuel consumptions and other associated parameters

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Modification done in inlet chilled water system –condensate recovery

The plant consists of three chiller units for chilling inlet air to the gas turbine for increasing gas turbine output and efficiency. In the process of chilling the air, chiller circuit generates 15 to 20 m3/hr of condensate depending on ambient condition. This condensate can be used as intake to DM plant as the water is of high quality. In the present system, water is disposed into storm drains.

The capacity of DM plant is 30 m^3 per hour. Modification done in the system to pump 15 m^3 condensate to clarified water tank, thereby reducing the raw water pumping to clarifier tank for DM plant requirement by 50 percent. This will reduce running hours of River water pumps and raw water pumps thereby saving the power consumption of these pumps.

Energy saving Calculation

Calculation of kW of Motor required for pumping of raw water to DM Plant intake at the rate of 30 cubic meter per hour.

The rated flow of river water pump is 400 m^3/hr and DM plant intake is 30 m^3/hr

Energy consumption of river water pump for DM water generation

= 30/400 x 45 kW = 3.4 KW

The rated flow of raw water pump is 300 m^3 / hr and DM plant intake is 30 m^3/ hr.

Energy consumption of raw water pump for DM water generation

= 30/300 x 45 kw = 3.7 kW

Total energy consumption of river and raw water pumps for DM generation

= 3.4 + 3.7 **= 7.1 kW**

Assuming all the six chillers are in service:- With the modification by routing the chiller condensate water to clarifier tank , the quantity of condensate recovery is 15 cubic meter per hour thus reducing quantity of water pumped from the river got reduced by 50% for DM water generation.

The saving of energy consumption for DM water generation

= 7.1/2 = **3.5 KW**

In a day DM plant normally operates for 14 hrs for full load operation of the Plant.

The saving of energy consumption for DM water generation per day

= 3.5 x 14 hrs = 49 KWH

Kwh saving per hour = 2.04

Yearly kWh saving = 2.04 x 8000=16320

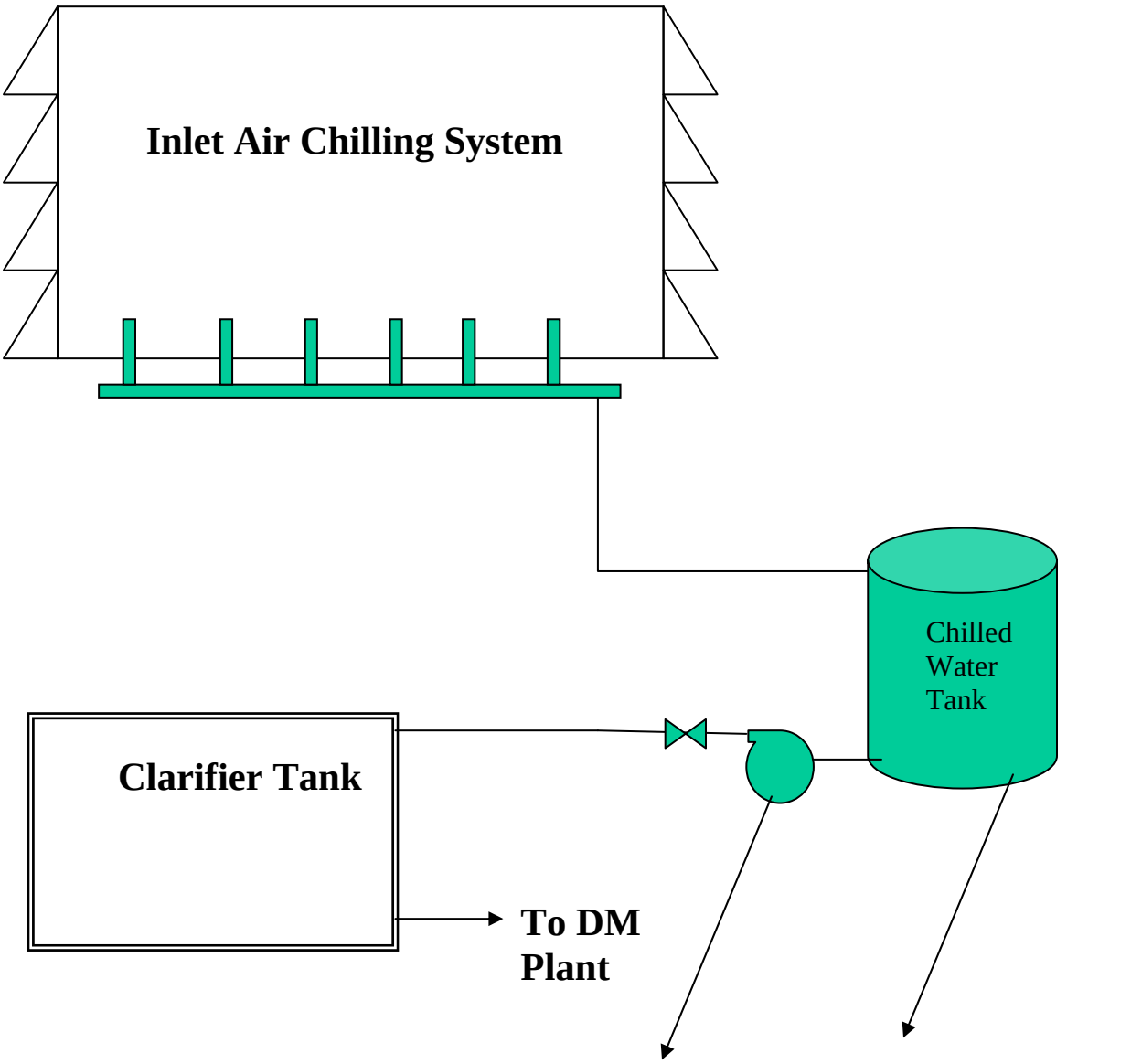
(Assuming 8000 hrs of operation per year)

Cost of electricity per KWH = Rs 4

Yearly Savings = 16320x4 = **Rs 65280**

Cost of implementation (Sintex Tank, PVC piping to Clarifier tank, motor & pump unit of capacity =Rs 50000

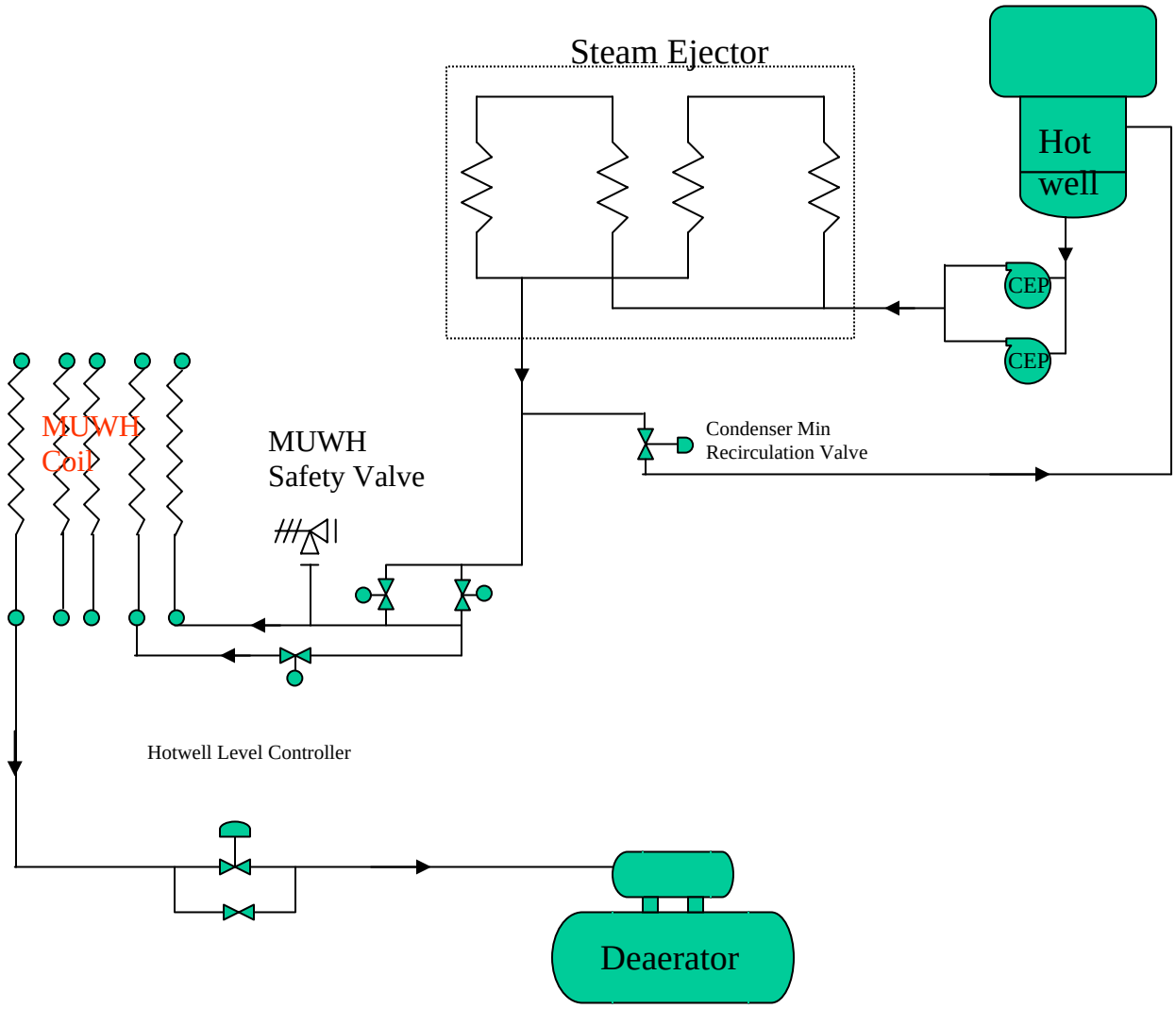
The implemented scheme is shown as below.



2.2kW motor pump set chilled water tank – (5000 liter)

CONDENSATE SYSTEM – CONDENSATE EXTRACTION PUMP MODIFICATION

System Overview



Back ground

Condensate Extraction Pump (CEP), one of the main auxiliaries of the steam turbine , is to pump the condensate from Condenser hot well to De-aerator. There are two CEP's. One will be running and the second is a hot standby. The total discharge head of the pump is 17.2 kg/cm^2.Condensate is pumped to the de-aerator through Make Up Water Heater (MUWH) which is the last stage of the HRSG. The rated operating pressure of MUWH pressure is 11 kg/cm^2. Presently the system operates with a pressure of 15 kg/cm2 which is 4 kg/cm2 more than the rated operating pressure. It can be seen from the performance curves provided by the Original equipment manufacturer that flow remaining constant, the pump input power required increases as the header pressure goes up (performance curve). This means increased auxiliary consumption. Hence it is proposed to bring down the input power required by reducing the header pressure.

Modification

The Condensate extraction pump (CEP) is a vertical, multistage centrifugal pump with five stages. It develops a total head of 17.2 Kg/cm2. Presently the system operating pressure is more than the rated pressure. So the system pressure can be reduced by reducing the pump discharge pressure. The reduction in pressure can be achieved by either trimming the impeller or by removing few of the stages. Trimming the impeller will affect the pump discharge flow. Hence it is decided to achieve the pressure reduction by removing one stage from the pump. After the stage removal the pump is with three stages and the removed stage will be replaced with spool piece. Finally the pump will be balanced dynamically. Details are given below.

Benefits

The operating details of the pump before and after the proposed stage removal are shown in the following tables.

Operating details before modification

Pump	Rated KW	No of stages	Operating KW	Operating Head(kg/cm^2)	Flow (m^3/hr)	Motor load(%)	Motor efficiency(%)
CEP	180	5	146	17.2	195	81.1	93

Operating details after stage removal

Pump	Rated KW	No of stages	Operating KW	Operating Head(kg/cm^2)	Flow (m^3/hr)	Motor load(%)	Motor efficiency (%)
CEP	180	4	116	14	195	64.4	92

The savings arising out of implementation of the above proposal can be calculated as follows:

Pump with 5 stages

1) Input power to pump at 195 m^3/Hr = 146 kW

2) % of motor load = (146/180) x100 = 81.11%

3)Motor efficiency at 81.11% load = 93%

(From rotor load vs efficiency curve No.48145T404-11/6)

Input power to motor = $\frac{\text{Pump Input Power X 100}}{\text{Motor efficiency}}$

= $\frac{146 \text{ X } 100}{93}$ = 156.98 kW

Pump with 4 stages

Input power to pump at 195 m^3/Hr = 116 kW (approx)

% of motor Load = $\frac{116 \text{ X } 100}{180}$ = 64.44%

Motor efficiency at 64.44% Load = 92%

(From rotor load vs efficiency curve No.48145T404-11/6)

Input Power to motor = $\frac{116 \text{ X } 100}{92}$ = 126 kW

Kw saving =

(Input power to Motor with 5 impeller –

Input power to motor with 4 Impeller)

= 156.98 – 126

= **30.98 kW**

Kwh Saving per hour = 30.98 kWH

Yearly KWH saving	**= 8000 x 30.98 = 247840**
(Assuming 8000 hrs of operation per year)	
Cost of electricity per KWH	= Rs 4
Savings per hour	= 30.98 x 4 = **Rs 123.92**
Yearly saving	=123.92 x 8000
	= **Rs 991360**
Cost of implementation	= Rs 100000

LP BOILER FEED WATER SYSTEM

Back ground

The plant consists of 3 Gas turbine's, 3 HRSG's and One steam turbine .The exhaust flue gas from the gas turbine is used for generating steam in HRSG and steam is admitted to the turbine Boiler feed water pump is one of the major auxiliary equipments of the combined cycle power

plant. HRSG is a dual pressure type where HP and LP feed water pumps are provided to feed water to the drums. The LP feed water pumps are driven by LT motors

There are two LP Boiler Feed water Pumps (LPBFP)of which one is running and other is standby. The LPBFP,s are of multi stage centrifugal type with five stages and having discharge pressure of 25 ksc. The power rating of pump is 55KW .

Since the rated pressure of LP drum is 13 ksc ,LP feed control station of the HRSG throttles the LP feed water pressure from 25ksc to 13 ksc.

The operating load of feed water pumps is varying between 60 to 65%. The details are given below

Pump	Rated kW	Opr. KW	Hz	% Loading
LP Feed Water Pump-1	55	34.3	49.4	62.36
LP Feed Water Pump-2	55	34	49.0	61.8

Modification

As the pressure developed by the pump is much more than the required pressure of LP drum there is a margin for reducing the discharge pressure of the pump. This can be done by removing few stages of the pump which results in saving of power consumed by the pump.

From the performance curve provided by the manufacturer, it is observed that the four stages can deliver the pressure of 20 ksc, which is sufficient for feeding LP drum having rated pressure of 13 ksc. Hence it is decided to remove one stage of the LP feed water pump.

Benefits

The operating details of the pump before and after the proposed stage removal are shown in the following tables.

Operating details before modification

Pump	Rated kW	No of stages	Operating kW	Operating Head in	Flow (m^3/hr)	Motor load(%)	Motor efficiency(%)

				Kg/cm^2			
LPBFP	55	5	36	25	50.65	65.5	92.5

Operating details after modification

Pump	Rated kW	No of stages	Operating kW	Operating Head(kg/cm^2)	Flow (m^3/hr)	Motor load(%)	Motor efficiency(%)
LPBFP	55	4	28.51	20	50.65	47.27	91

The savings arising out of implementation of the above proposal is calculated as follows:-

Pump with 5 stages

1) Input power to pump at 50.65 m3/Hr = 36 KW

2) % of motor load = (36/55) x100 = 65.5%

3) Motor efficiency at 65.5 % load = 92.5%

(From rotor load vs efficiency curve No.48145T404-11/6)

Input power to motor = $\frac{\text{Pump Input Power X 100}}{\text{Motor efficiency}}$

= $\frac{36 \text{ X } 100}{92.5}$ = 38.91 kw

Pump with 4 stages

Input power to pump at 50.65 m3/Hr = 26 KW (approx)

% of motor Load = $\frac{26 \text{ X } 100}{55}$ = 47.27%

Motor efficiency at 47.27% Load = 91%

(From rotor load vs efficiency curve No.48145T404-11/6)

Input Power to motor = $\frac{26 \text{ X } 100}{91}$ = 28.51 KW

Kw saving

=(Input power to Motor with 5 impeller – Input power to motor with 4 Impeller)

= 38.91 – 28.51 = 11.4 **KW**

Kwh saving per hour =11.4 kwh

Yearly kwh saving **=11.4 x 8000= 91200 kwh**

(Assuming 8000 hrs of operation per year)

Cost of electricity per KWH = Rs 4

Savings per hour = 11.4 x 4 = **Rs 45.6**

Yearly saving **=45.6**x8000(assuming 8000 hrs of operation per year)

= **Rs 364800**

Cost of implementation = Rs 100000

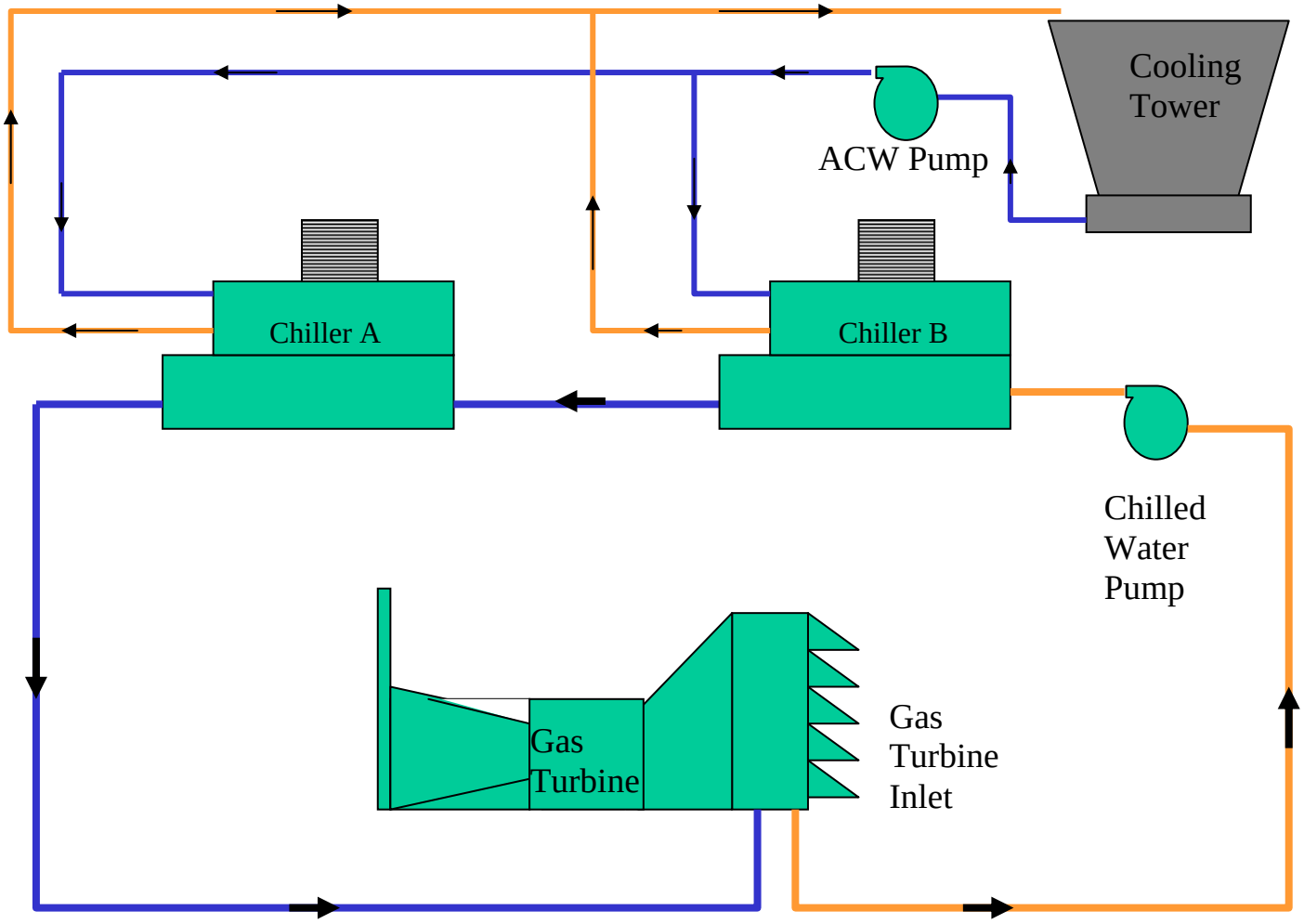
INLET AIR CHILLING SYSTEM - MODIFICATION

Background

The chiller system used to increase the power generation in the gas turbine by reducing the inlet air temperature to the compressor of the gas turbine. The gas turbine output increases as the mass flow of air increases provided other variables are kept constant. With the constant volumetric flow of a gas turbine, by increasing the inlet air density, more mass flow is achieved. The power produced by the turbine is nearly a linear function of air mass flow rate.

The chilling system use the refrigerant to provide the heat transfer needed to lower the gas turbine inlet air temperature. The chiller system composed of compressor, evaporator, condenser, economizer & chilled water pump .The refrigerant distributed along the length of the evaporator. The liquid refrigerant absorbs the heat from the water circulating through the evaporator tubes to vaporize. The gaseous refrigerant is compressed and discharged into the condenser. The cooling tower water absorbs the heat from the refrigerant. The liquid refrigerant flows of the condenser, passing through an orifice into the economizer. The economizer reduces the energy requirements of the refrigeration cycle by eliminating the need to pass all gaseous refrigerants through both stages of compression.

The chilled cooling water from the evaporator is discharged into the cooling coil in the air inlet duct. As inlet air passes over the cooling coil, the temperature of the air decreases along the constant wet bulb temperature. As the inlet air passes over the chilled coil, the water vapor content (humidity ratio) remains constant as it decreases in temperature up to the saturation curve. If the inlet air is cooled further, the water vapor will condense out of inlet air.


Cooling
Tower
ACW Pump
Chiller A
Chiller B
Chilled
Water
Pump
Gas
Turbine
Gas
Turbine
Inlet

Modification

The inlet air to gas turbine is chilled to 8° C for achieving the desired output and heat rate. There are two chillers for each gas turbine rated 640 KW and 585KW. The inlet air after filtration passes through the chilling coils via inlet ducts and reaches the compressor bell mouth.

The portion of the chilled air compartment and duct exposed to the ambient environment is approx.230sq.m. It recommended to insulate the inside of the turbine compartment. With this in view, we approached M/s.Beardsell Limited, who has proposed insulating with Nytral rubber insulation (Vidoflex) 38mmthick.

It is recommended to insulate the complete chilled air compartment and duct with EPS and Nytral rubber

Details of Insulation done

A) Vidoflex Nytral rubber :-

Considering ambient temperature variation from 26 degree to 33 degree and the chiller temperature 8 degree, related humidity 90%, the thickness recommended is 38mm in two layers. (19mm+19mm)

B) Isobuild EPS panels (Expand Poly Sterene – known as Thermocole)

As per the calculation, the thickness of EPS panels should be 100mm with one side GI coated sheet and other side EPS .The same thing will be fixed with the existing MS plate walls and ceiling with necessary angles. Adhesive, silicon sealant etc

Assumptions: Compartment and duct exposed reaches 55^{o}C metal temperature. Turbine compartment temperature remains at 55^{o} C

Data: Loss per sq.mt with out insulation is 357 W/M^2

The net saving shall be 280 X 357 = 99960 watts say approx 99KW per turbine

Cost of supply and application expand poly sterene = Rs 140 / sq.ft

= 1505 / sq.mt

For 230 Sq mt. Approx cost is Rs 3,46,000

Cost of supply and application of 38mm thick nitril rubber insulation

Rate Rs.220/ sq ft = Rs.2365/sq.mt

For 50 sq .mt. approx Rs 1, 20,000

Total expenditure Rs 4, 70,000 per gas turbine.

Benefits

Heat loss calculation

1) when there is no insulation

$$Q = \frac{t1-t2}{(X/k)+(1/f)}$$

t1 = Hot side temperature 55C
t2 = Cold side temperature 8c
x = Thick ness of MS plate CM
k = Thermal conductivity of MS mw/cm C
f = Surface co-efficient of MS mw/cm2 C

$$= \frac{55-8}{(0.6/520)+(1/0.79)}$$

$$= \frac{47}{1.266977}$$

= 37.09619 mw/cm2

= 370.9619 w/m2

Say 371 w/m2

When there is Insulation

$$Q = \frac{t1-t2}{(X/K1)+(X2/K2)+(1/0.79)}$$

$$= \frac{55-8}{(10/0.3)+(0.6/520)+(1/0.79)}$$

$$= \frac{47}{34.60031}$$

= 1.358369 mw/cm2

= 13.58369 w/m2

For an area of 125 Sq.m the saving will be 357.3781X125

= 44672.27 watts

= 44.67227 KW

Kwh saving per hour = 44.67

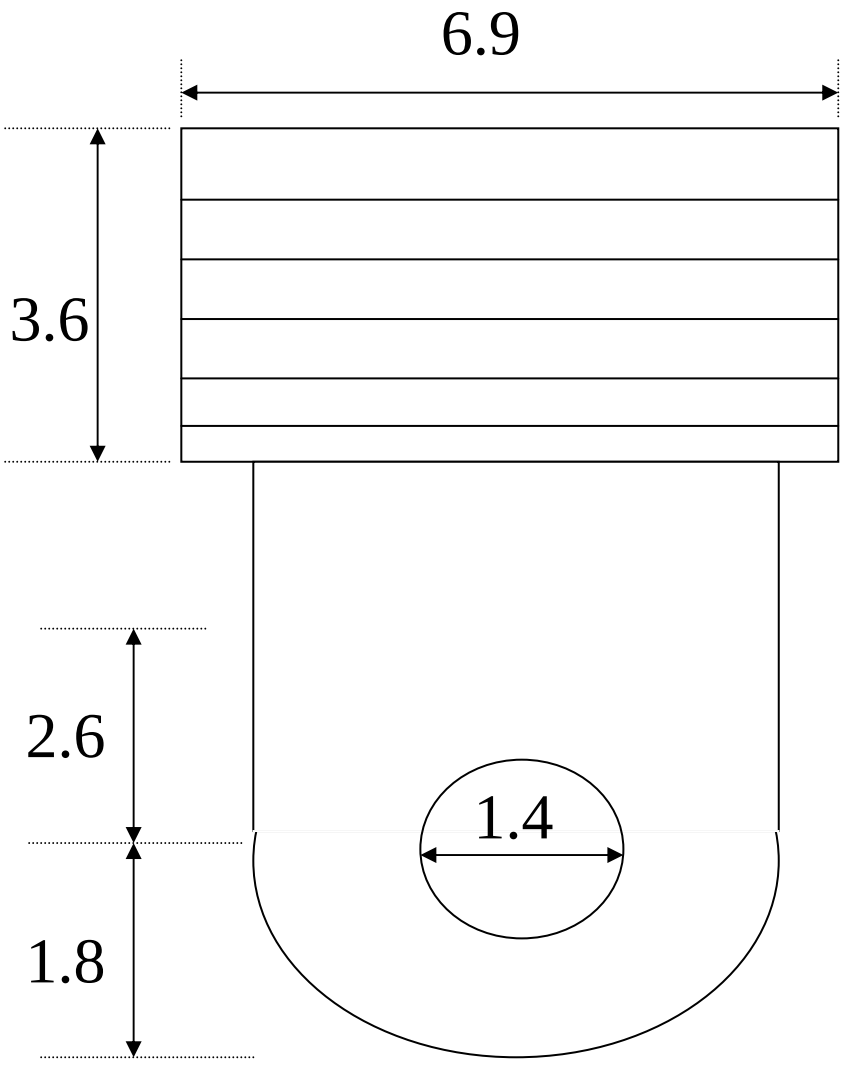
Yearly Kwh saving =44.67x8000=357360
(Assuming 8000 hrs of operation per year)

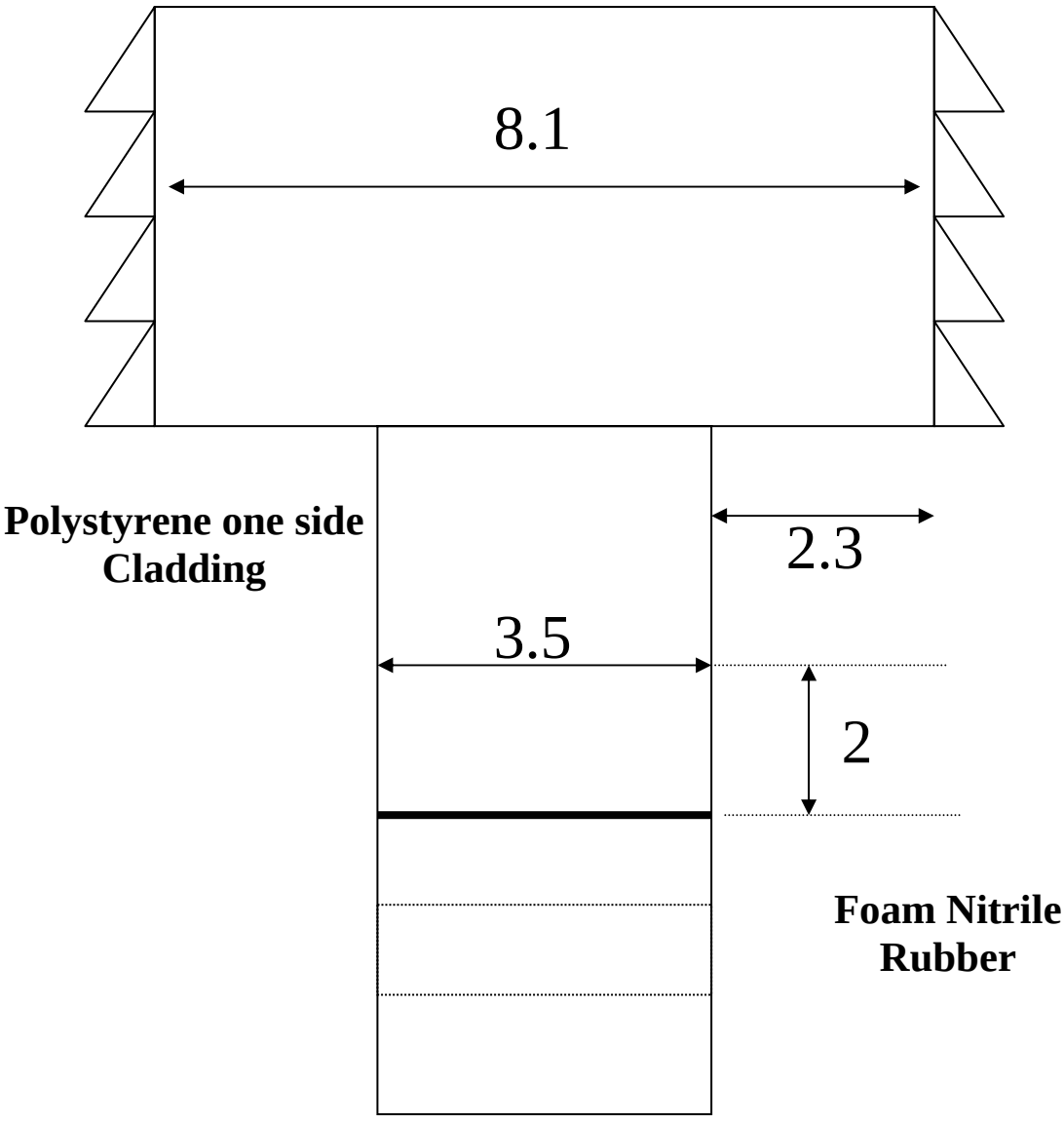
Cost of electricity per KWH = Rs 4

Yearly saving = 357360x4
= Rs1429440

Cost of implementation = Rs 295625

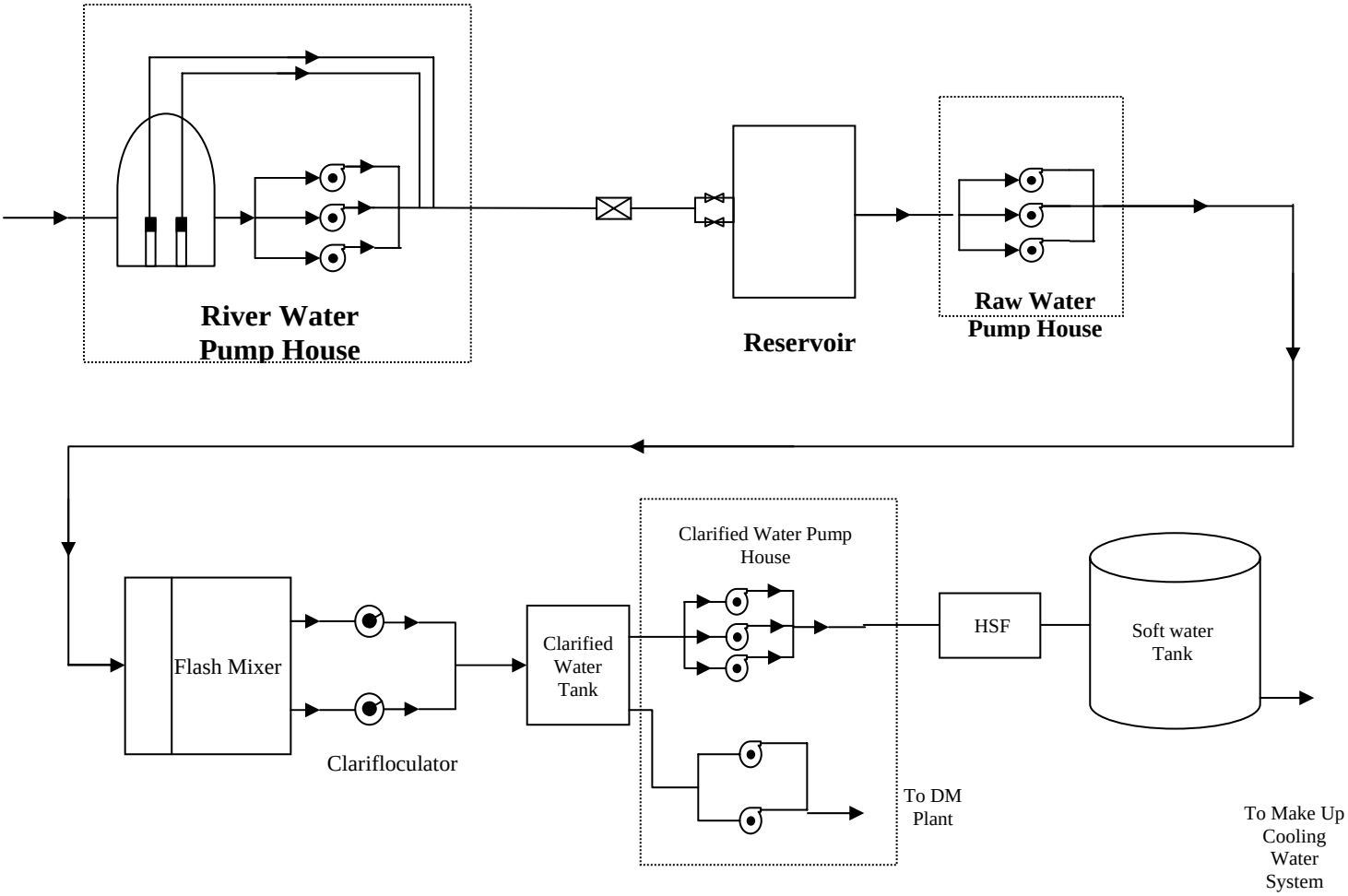
VIEW OF GAS TURBINE SKID AND AIR FILTER DUCT


6.9
3.6
2.6
1.4
1.8


8.1
Polystyrene one side
Cladding
2.3
3.5
2
Foam Nitrile
Rubber

RIVER WATER SYSTEM & RAW WATER SYSTEM MODIFICATION

System overview



Background

The main source of water for the plant is River Periyar, which is 1 KM away from the plant. The water is used for cooling of Steam Turbine condenser, various Gas Turbine and Steam Turbine auxiliaries, and service purpose. The river water pump house is located near the river, which consists of three river water pumps and two submersible pumps. These pumps transfer water from the river to reservoirs.

River water pumps will be in service during normal level of the river. Submersible pumps will be in operation during low tide conditions.

The river water pumps are vertical, centrifugal pumps having capacity of 400 m^3 / hr. The water consumption per day is 5500 m^3 / day. Normally two River Water pumps will be in service for 7 hrs. The two reservoirs are having capacities of 4800 and 6000 m^3 each. From reservoir, raw water pumps pump the water to clarified water tank through stilling chamber, flash mixer and clarifloculator. The clarified water from the clarified tank is fed to soft water tank by clarifier pumps through sand filters. The soft water is used as make up water for cooling water system. There are three pumps for softener stream, each of 250 m3/hr capacity and two pumps for transferring water to DM plant each having a capacity 40m3/hr. Out of two DM transfer pumps one will be in operation continuously.

Modification - I

During normal operation, two river water pumps will be in service for seven hrs/day and one raw water pump for 15 hrs/day. The modification is carried out to tap a pipeline from intake of reservoir to stilling chamber as shown in figure below. When river water pump is in service, the water will be pumped to reservoir and to stilling chamber through this new pipeline. . This will save the power consumed by the raw water pump for 15 hrs/day. Details of Raw water pump, River water pump and Clarified water pump given in below

Energy saving

Energy consumption of raw water pump per day after the proposed modification.

= (existing scheme) – (proposed scheme)

= (37kw X 15hrs) – (37kw X 1 hr)

= 555 – 37

= **518 Kwh**

Kwh saving per day = 21.58

Yearly Kwh saving **= 8000 x 21.58 =1726**40

(Assuming 8000hrs of operation per year)

Cost of electricity per KWH = Rs 4

Savings per hour = 21.58 x 4

= 86.32

Yearly saving **= 86.32 x 8000**

= **Rs 690560**

Cost of implementation = Rs 110000

Modification – II

The water pumped from the river will go through stilling chamber and clarifloculator where the turbid water is dosed with alum to reduce the turbidity of water. This water will be fed to cooling water system make up and other systems. The cooling water system requires 190-200 m^3 / hr. Turbidity of cooling water system is less than six NTU. In this modification done to tap pipeline from intake of reservoir to cooling water sump. Whenever the turbidity of river water is less than six NTU, the water shall be pumped directly from river to cooling water sump for make up. This will save the energy consumed by raw water pumps, clarifier pumps, as these pumps will be bypassed with the proposed line.

The rated flow of raw water pump is 300 m^3/hr and the flow of clarified water pump is 250m^3/hr

Energy consumption of raw water pump = 37kw

Considering turbidity of the river water is less than 6NTU for a period of 5 hours / day

Energy saved (raw water pump) considering 80% of the rated load

= 37 x0.8x5

=148 units / day

Normally we operate two clarified pumps of rating 45kw each

Energy saved (clarified water pump) considering 80% of the load

=45x2x.8x5

=360 units/ day

Total energy saved in a day = 148+360

= 508 units per day

kWH saving per hour = 21.16

Considering the turbidity of river water is less than 6ntu for 50 days in a year energy saved = 21.16x24x50

=25392 units / year

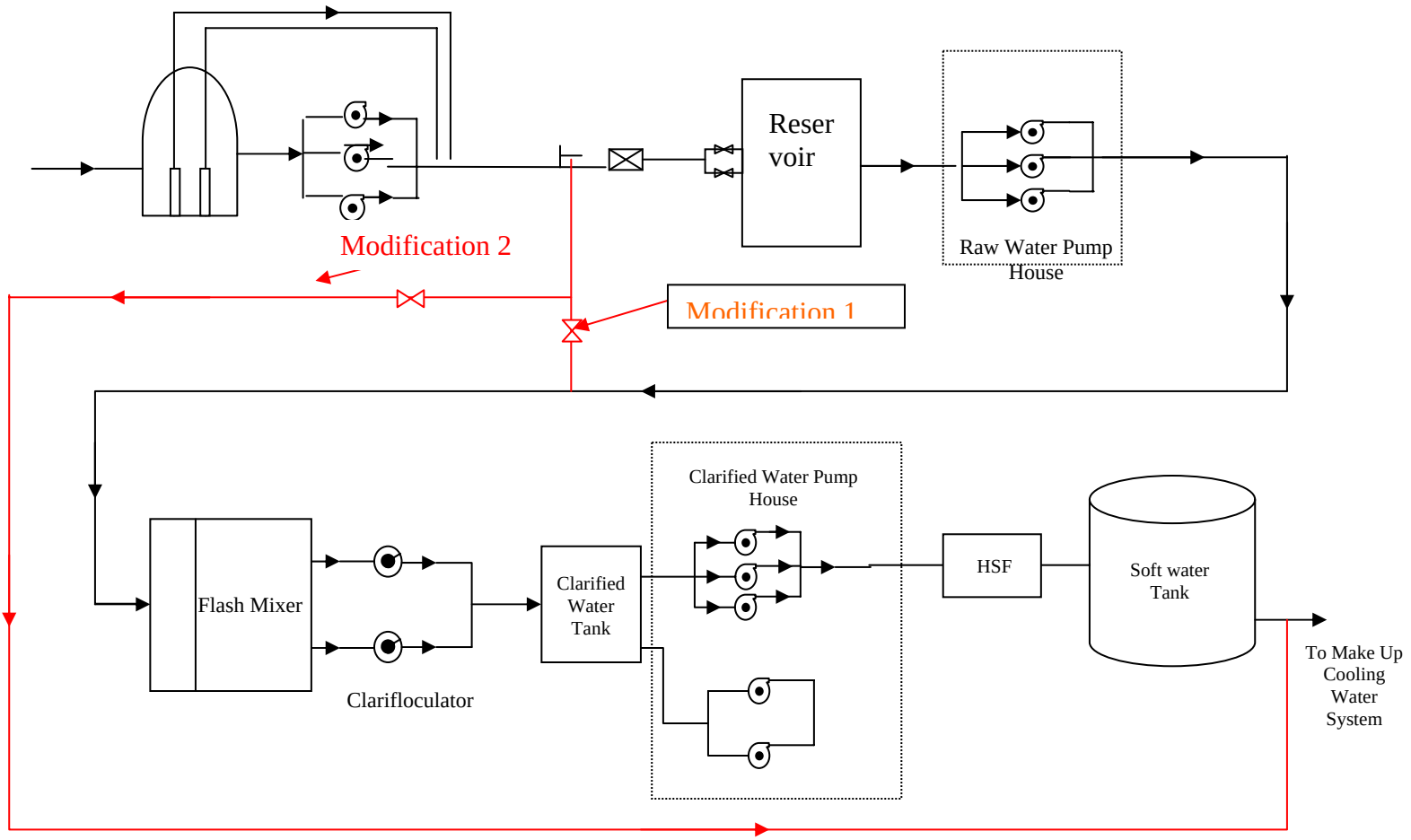
Cost of electricity per KWH = Rs 4

Yearly saving **= 25392 x 4**

= **Rs 101568**

Cost of implementation = Rs 25000

Fig 4.2.2



The Name Plate details of the pump motor set are as below.

River Water Pumps

	Quantity	:	3 Nos
Pump	Make	:	Kirlosker
	Type	:	BHR 35-18
	Size	:	250 mm
	Capacity	:	400 M^3/ Hr
	Head	:	25.2 M
	Imp. Dia.	:	336 mm
	Imp. Material	:	CF8M
	Sr No	:	1531198019 / 20 / 21
Motor	Make	:	Kirlosker
	Rating	:	45 KW , 415 Volt , 74.5 Amp
	Frame	:	VSC 225 M
	Speed	:	1475 RPM
	Class / Duty	:	F / S1
	Encl / Freq	:	IP55 / 50 Hz
	Bearing :		DE / NDE N313 / 6313
	Sr No	:	985 P 656-01 / 02 / 03

7.2 Raw Water Pumps

	Quantity	:	3 Nos
Pump	Make	:	Kirlosker
	Size	:	200 mm
	Type	:	BHR 28 - 30
	Capacity	:	300 M^3 / Hr
	Head	:	15.27 M
	Imp. Dia	:	258 mm
	Imp.Material	:	CF8M
	Sr No	:	1530198012 / 3 / 4
Motor	Make	:	Kirlosker
	Rating	:	37 KW , 415 Volt , 38 Amp
	Class / Duty	:	F / S1
	Encl / Freq	:	IP55 / 50 Hz
	Frame	:	VSC 180 L
	Speed	:	1470 RPM
	Bearing	:	DE / NDE Both 6310 ZZ
	Sr No	:	398SH6173-01 / -02 / -03

NATIONAL ENERGY CONSERVATION AWARD –2008
SUMMARY SHEET

1	Name	BSES Kerala Power Ltd		
2	Address	165 MW Power Plant, Udyogamandal.P.O, Ernakulam (Dist), Pin:- 683501		
3	Nature of business	Power Generation	7.Capital invested	Rs. Cr: 594
4	Product mix (product name and specifications)**	Product1: **Electricity Generation** Units per year:- **Installed capacity :- 165MW**		

5 Energy conservation activities undertaken during the last 3 years

Year	Project/Program/Activity Title	Category (Put code no. from below)	Project cost (Rs. lakhs)	Annual Savings: Electricity (MU)	Annual Savings: Fuel tons	Total Annual cost savings (Rs.lakhs)
2005 – 06	(1)Chiller condensate recovery	D	0.50	0.01632	3.056	0.6528
	(2) LP BFP & CEP one stage removal	D	2.25	0.3390	63.46	13.56
	(3) GT Filter house insulation work	D	3.50	0.3570	66.83	14.29
	(4) River water & raw water system modification	D	0.025	0.0254	4.75	0.102
2006-07	(1) Horizontal sand filter conversion for side sand filtration for Cooling Tower returns water.	D	0.045	-	-	0.75(Annual Saving in terms of water cess payment)
	(2) Rain water harvesting of Service building.	F	0.010	-	-	0.0013(Annual Saving in terms of water cess payment)
	(3) Replacement of indicating bulbs to LED indicating lamps in switchgear panels	D		1296kWh	-	0.082 (Annual Saving in terms of fuel for Electricity production)

2007 - 08	(1) GT # 3 Installation of VIGV for the improvement of part load heat rate	D	US $- 463632/-	--	13.072	5.48
	(2) GT # 1, 2, 3 implementation of upgraded software for control system for the reliability improvement to avoid spurious tripping.	D	US $ 29924 /-	--	3.081(per shut down &start up)	13.25lacs(per shut down &start up)
	(3)CRT monitor changed to LCD Monitor for all office computers	D	2.2	0.00462	0.812	0.0037(Annual Saving)

Category	Code no.		Category	Code no.		Category	Code no.
House keeping	A		Inter fuel substitution	C		Cogeneration	E
Efficient operation	B		Technology up gradation	D		Others	F

NATIONAL ENERGY CONSERVATION AWARD –2008
SUMMARY SHEET

17	Details on training programs/campaigns in energy Conservation organized/conducted in 2007-08.	(1) A seminar on Energy conservation awareness, and about - LED lighting and Solar Lighting by Mr. Georgekutty Kariyanappally, Managing Director, Lifeway Solar Ltd was conducted on 10/09/2007 for all Employees. (2) Two Executives of Electrical department was deputed for a two days training on Energy conservation at Kerala State Productivity council, Kochi. (3) Two executives of Electrical department were deputed for three days training on Performance improvement and condition monitoring & Energy Conservation at Institute of Energy Management, Hyderabad. (4) Three executives from Operation and maintenance department were attended three days workshop on "Life Long training Programme on Energy Conservation Of Power Plants" – conducted by Bureau Of Energy Efficiency at DTPS-Mumbai and at New Delhi.
18	Details of innovative technologies implemented for energy conservation including utilization of renewable energy.	The recommendation of Energy audit done in April 2008 are listed and action taken during the year 2008 and action Plan for coming years is listed.

Details on activities and energy consumption **for the last three years** (2005-2006, 2006-2007 and 2007-2008) as indicated below may be given in separate sheets specifying clearly the units, type of fuel, etc.
Industries:- Production, Electricity & Fuel(s) consumption, Total energy cost, Specific energy consumption (separate for electricity & fuel) supported by annual reports for the above years.
Hotels/Hospitals/Buildings:- Operating cost, Electricity & fuel cost, Occupancy, if applicable.

Non-profit organisations:- Budget & expenditure towards energy conservation projects

Transport organisations:- Distance covered, fuel consumed and kilometer per litre.

What is your current fleet fuel economy ?

What type of equipment do you operate in your fleet?

What is your average km traveled per vehicle and average carrying capacity(passenger and load)

Please identify which measures you have used for an improvement in fuel economy and briefly describe the benefits:

Measures (Please describe briefly actions taken or policy)

Improve engine technology

Improve vehicle specifications, aerodynamics

Install fuel performance display on dashboard

Driver training in fuel economy? Refresher training? How often?

Tire pressure – How often do you check tire pressure?

Checking fuel tank cap and radiator caps

Checking injectors, filters and Air Leakages

How often do you change your engine oil?

Speed policy – Has it changed over the past two years? How?

Reduced idling – Do you have automatic shut-off?

Incentive program – Do you publicise and reward best performance in the fleet?

Vehicle maintenance practices – Do you have a preventive program?

Manufacturers/traders/dealers:- Sales volume of the energy saving products & savings

Research & Innovations: Brief Concept Note on the objective, Scope of research activity, results achieved, funding assessment if any etc. attaching proof of the same.

Individuals:- Details on the achievements attaching proof of the same.

* Applicable to enterprises/organizations.

** Applicable in the case of manufacturing industries. In case of service sector appropriate parameters shall be provided eg. In the case of hotel industry could be percentage occupancy.

Authorized Signatory

Name & Designation: - P. Sudhanshu Gupta

Plant In Charge

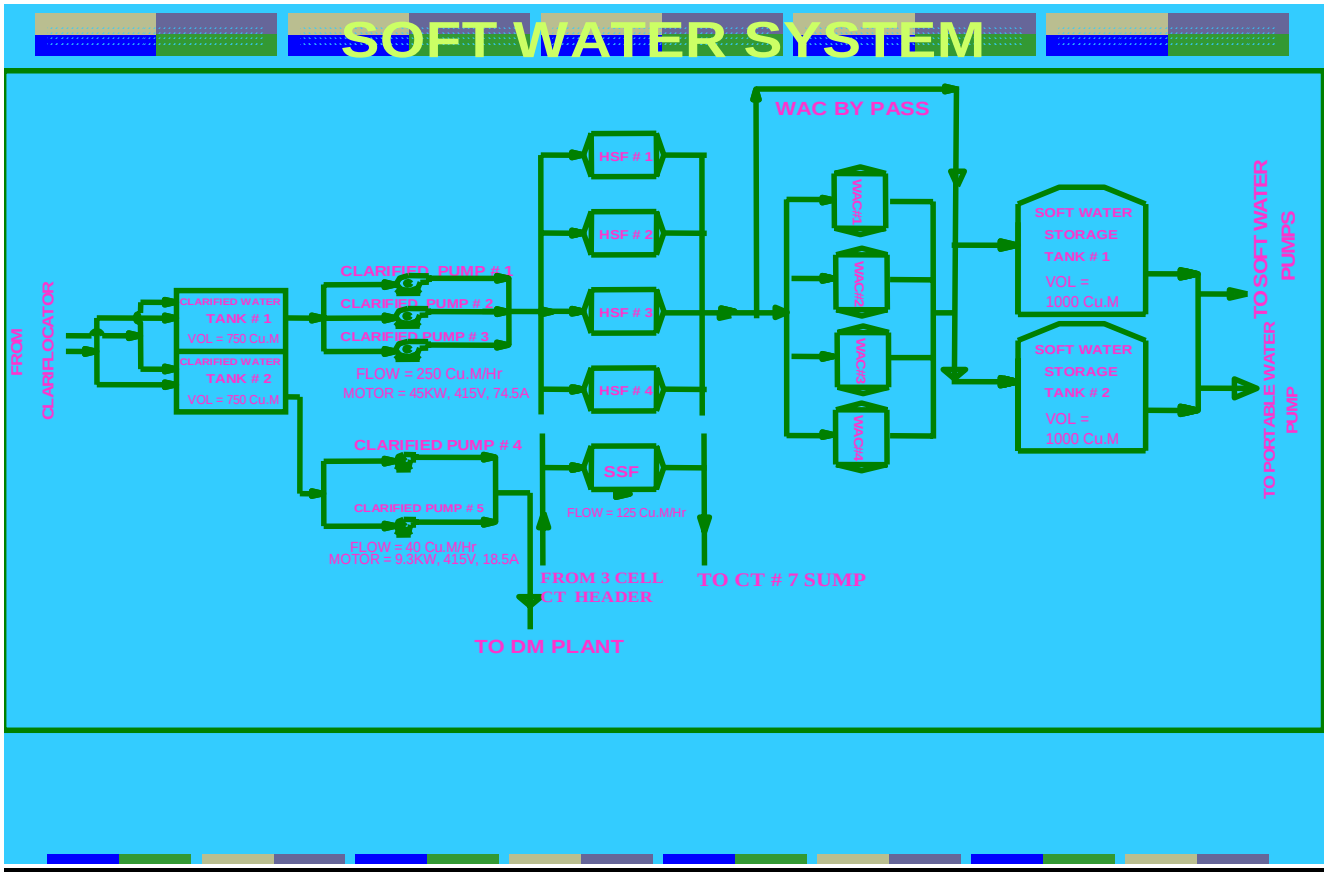
(Office Seal)

Please return to: The Director, Energy Management Centre-Kerala, Dept. of Power, Govt. of Kerala, Thycaud P.O., Thiruvananthapuram 695 014. Telephone: 0471-2323363.
e-mail: ecaward@keralaenergy.gov.in

Converting Horizontal sand filter to side stream filter in cooling water Stream

The Pre treatment system after Clarifier storage tank: - From clarified water storage tank water is pumped by clarified water transfer pump for Soft water & DM water generation through 5 Nos of Horizontal Sand filter (HSF). Initially system is designed to use 5 Nos of HSF to utilize the softener stream. As the Water receiving from River Periyar is of good quality and lean water, we are bypassing the Softener stream in DM Plant. So one number Horizontal Sand filter has become idle/stand by.

The idle capacity of horizontal sand filter is utilized by converting it to Side Stream filter in cooling water stream. The tapping from return header of 3 cell cooling return water is routed thro HSF # 5 in the Filtration area of DM Plant and out let is discharged in the Cooling Tower # 7 sump.
This modification helps to achieve the reduction in cooling water make up and in the cooling water blow down.
The modification done is as per the diagram below.



Saving Calculation

EFFECT OF SIDE STREAM FILTRATION IN THE REDUCTION OF MAKEUP WATER FOR RECIRCULATING COOLING TOWER OPERATION

Recirculation Rate(RR) at full load plant operation:

1 MCW + 3 ACW pumps = (7700+3588) cu.meter/hr circulation = 11288 m3/hr

Evaporation Rate = 11288*10*0.85/1000 (E V = RR*Delta T*F/1000

Where RR= Recirculation Rate = 11288 m3/hr
Delta T = Temp. Difference = 10 Deg.C
F = Evaporation Factor= 0.85
E V = Evaporation rate
= 95.95 ~ 96 m3/hr

Blow Down (BD) = E V /COC

(Where COC stand for Cycle of Concentration, Initially Plant operated on COC 6, after Side Sand filter installation COC increased to 8 and now further increased to 10 COC. This has resulted to gradual decrease in make up water quantity and thus saving in water quantity)

Blow down at COC 6 = 96/5 m3/hr
= 19.2 m3/hr(460.8 m3 per day)
Make up at COC 6 = (96 + 19.2) m3/hr (make up = E+BD)

= 115.2 m3/hr(2764.8 m3 per day)

Make up at COC 8 = (96 + 96/7) m3/hr
= 109.7 m3/hr (2633 m3 per day)

Saving at COC 8 = (2764.8-2633) = 131.8 m3 per day

Make up at COC 10 = (96+ 96/9) m3/hr = 106.66 m3/hr(2560 m3 per day)

Saving at COC 10 = (2633-2560) m3 per day = 73 m3 per day

Over all saving from COC 6 to COC 10 = (2764.8-2560) m3 per day

= 204.8 m3 per day

Saving in terms of cess payment (Rs.) = 204.8*365

= **74752 per year**

Rain water harvesting works taken up in BKPL for the year 2007

The rain water harvesting of Plant Buildings are planned as per the programme below.

PROGRAMME FOR RAIN WATER HARVESTING.

	NAME OF BUILDING	APPROX ESTIMATE	YEAR OF EXECUTION	REMARKS
Phase#1	Service building.	Rs: 10000/-	2007	Service buildings roof rainwater diverted to reservoir by laying PVC pipes along Pipe and cable rack.
Phase#2	STG/PCR Building.	250000	2008	STG/PCR Buildings roof rainwater diverted to reservoir/clarified water storage tank by laying PVC pipes along Pipe and cable rack.
Phase#3	ADMN/DG Building.	100000	2009	ADMN/DG Buildings roof rainwater diverted to reservoir/clarified water storage tank by laying PVC pipes along Pipe and cable rack.
Phase#4	GCR/DM Building.	100000	2010	GCR/DM Buildings roof rainwater diverted to reservoir/clarified water storage tank by laying PVC pipes along Pipe and cable rack.

The Phase # 1 works completed in the year 2007

Rain water harvesting facility of Plant Service building roofs for about 400 m^2 has been established by tapping roof drains to a common header of pipe line of size-4 inches and routed to Reservoir. Considering an yearly average rainfall of about 3021 mm, a total saving of 1208 m^3 of water.

The PVC piping and other materials for the works were available and Manpower cost for the implementation was Rs-10000/-.(Ten thousand)

The per year saving on account of pumping cost and cess charge comes to Rs. 1208. (The water cess charge is Rs – 1 per cubic meter of water)

The phase # 2 works for PCR and STG building, Material procurement done and work execution in progress.

Replacement of Panel indicating bulbs to LED indicating lamps in switchgear panels

The Total population of panel indicating lamps in the switchgear is listed in the file: - Panel Lamp List.

During the year 2006-07 the replacement of about 74 indicating lamps in 6.6kV switchgear Panels were carried out.

The Energy saving calculation is as below.

The wattage rating of one filament type indicating lamp : - 2.7watts.

The wattage rating of one LED indicating lamp suitable to the panel indicating lamp :- 0.7watts

The saving per Indicating lamp from the above: - 2 watts.

The Energy saving from 74 indicating lamps changed during the year 2006-2007 = 148 watts.

The yearly Energy Saving = 0.148 X 8760 = **1296 kWh**

Annual saving of fuel from the Generation = **Rs – 8201** (1296 X 0.1808X Rs-35)

The life of one LED lamp as per the manufacturer is 7000hrs. So the cost of replacement of lamps comparing to filament type lamp is drastically reduced.

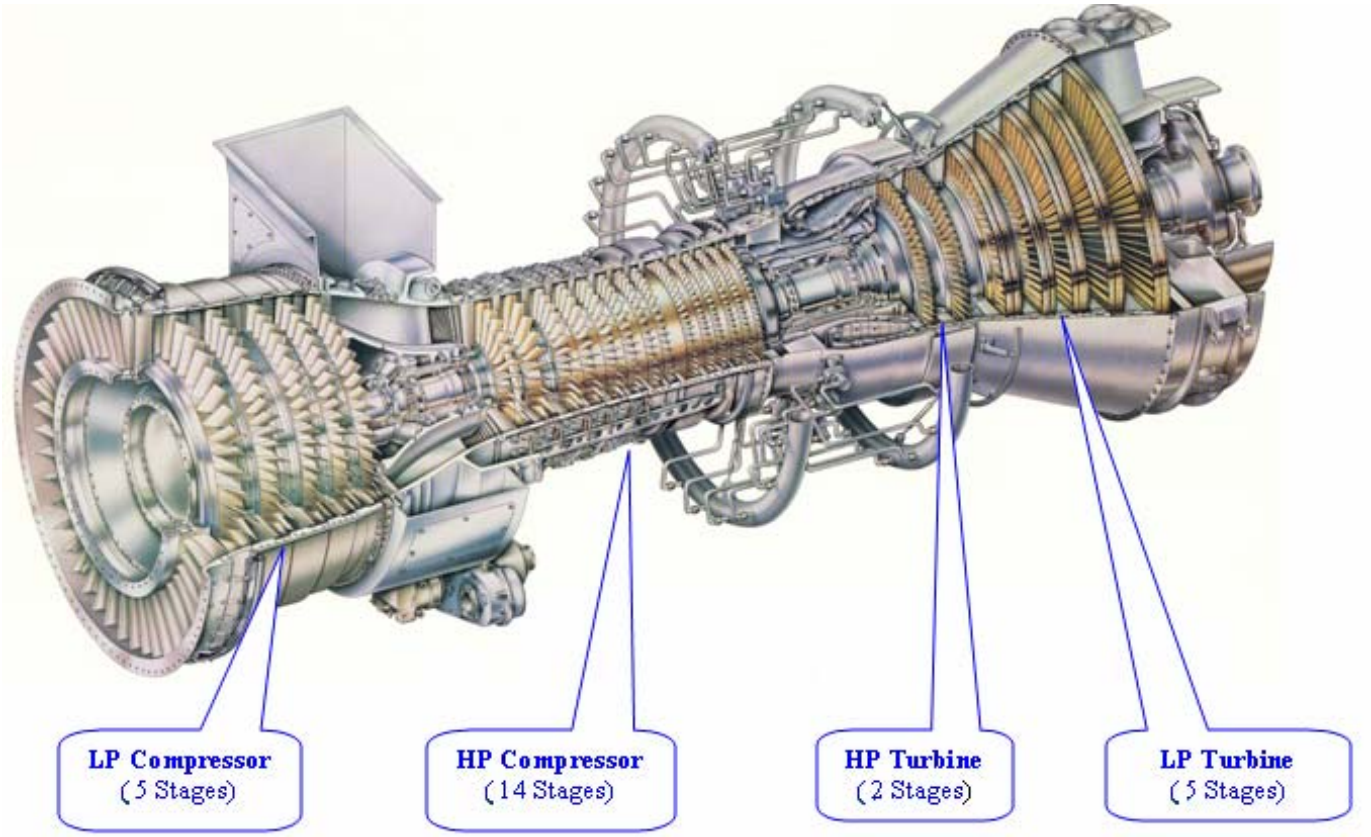
Implementation of VIGV in Gas Turbine # 3 for the improvement of part load heat rate.

The GE supplied LM 6000 Gas Turbine to this Plant is Dual rotor Gas turbine consists of fixed vane inlet frame assembly , Five stage LP compressor(LPC), Fourteen stage variable – geometry high pressure compressor(HPC), single annular combustor(SAC), two stage high pressure turbine(HPT), five stage low pressure turbine(LPT) and a transfer gearbox assembly and accessories.

The LP rotor shaft consists of LPC, LPT and flanges for power shaft for connecting Generator load. The high pressure rotor consists of 14 stages HPC and two stage HPT that drive the shaft. The high pressure core consists of HPC, Combustor and HPT. The air enters Gas turbine thro inlet frame and passes in to LPC. The LPC compresses the air by a ratio of approximately 2.4: 1. Air Leaving LPC is directed into the HPC. Variable by pass Valves (VBV) are arranged in the flow Passage between the two compressors to regulate the air flow entering the HPC at idle speed and at part load operations. To further control the airflow, the HPC is equipped with variable Stator vanes (VSVs). The HPC compresses the air to a ratio of approximately 12:1 resulting in a total compression ration of 30:1, relative to ambient. From HPC the air is directed in to annular combustor where it mixes with fuel from 30 fuel nozzles. The fuel air mixture initially ignited by an igiter and once combustion is self sustaining, the igniter is turned off. The hot gas that results from combustion is directed into the HPT which drives the HPC. This gas further expands through LPT, which drives the LPC and Generator.

The Variable by pass system located in the front frame assembly is used to vent LPC discharge air thro the LPC bleed air duct in order to maintain LPC stall margin during starting, partial load operations and in large power transients. The Variable geometry control system is designed to provide the excitation signal conditioning and to control VBV and VSV position by means of closed loop scheduling of VBV actuator position, based on LPC inlet temperature and HP rotor speed corrected to inlet conditions.

LM 6000 PC Cross Section



In order obtain the maximum efficiency and optimum heat rate from LPC & HPC the bleeding air thro VBV should be very minimum and closed in the full load operation.. So during the part load operations the bleed air thro VBV opening is more and hence affecting the efficiency. The regular dispatch instruction from KSEB was full load operation during peak hours in the day hours (16hrs) and part load operation at 75% load for off peak hours (8 hrs). The overall heat rate for the day was affecting due to high heat rate in the Part load operations of the Plant. This matter was discussed with OEM – GE Engineering and given the proposal for incorporating Variable Inlet Guide Vane instead of fixed inlet frame for controlling the air flow entering in to LPC. The proposal was discussed in detail and the work order issued to GE for material supply and implementation including software changes in the control system of variable Geometry System.

The project was completed in GT # 3 along with annual shut down of GT # 3 in the month of July 2007. The readings taken and the gain in Heat rate obtained in open cycle part load operation of GT # 3 is tabulated below.VIGV Installation in GT # 3

VIGV in fully closed position

VIGV in fully open position

Savings calculation

The Total cost of implementation was: - U S $- 463632/-

Gain in heat rate with VIGV (open cycle mode part load operation) = 28.43kcal/kwh

Saving of fuel = 0.0025 kg per kWh

Saving in fuel after implementation of VIGV in GT # 3 (from July 2007 to 31st march 2008)

The actual running hours of GT # 3 in part load after implementation of VIGV GT # 3 from July 2007 = 166hrs

Generation from GT # 3 operation in part load of 31.5MW for 166 hrs from July 2007 to 31st march 2008

= 5229000kWh

Saving of fuel gained with VIGV operation = 0.0025 X 5229000 = 13.072 tons

The average prize of fuel per ton = Rs - 41883.96

Fuel cost saving = 13.072 X 41884

= **Rs 547529**

				Without VIGV	**Without VIGV**	**With VIGV**	**With VIGV**
	Machine Condition						
1	DATE			16/07/2003	11/02/2005	07/03/2008	15/03/2008
2	Control Mode (T3, PS3, T4.8)			XNSD	XNSD	XNSD	XNSD
3	Ambient Pressure		PSIA			14.5725	14.49
4	Ambient Relative Humidity		%			77	85.33
5	Ambient Temp. Dry bulb		°F			78.98	87.35
6	Ambient Temp. Wet bulb		°F			73.4	83.81
7	T2, Compressor Inlet Temp (AVG)	TE-6821A/B	°F	**77.4**	**57.8**	**58.4**	**79.25**
8	Inlet Pressure		"H_2O			1.69	1.573
9	XN25 H.P. Compressor	SE-6800	RPM	10157	10050	9838	10004
10	XN2 L.P. Turbine	SE-6812	RPM	3623	3616	3582	3574
11	P0, Compressor Inlet Pressure	PT-6863	PSIA	14.38	14.6	14.45	14.4
12	P25 HP Comp. Inlet Pressure	PT-6959	PSIA	32	33	29	28
13	PS3A Comp. Discharge Pressure	PT6804	PSIA	342	355	327	317
14	PS3B Comp. Discharge Pressure	PT6814	PSIA	341	355	327	316
15	P48 L.P. Turbine Inlet Pressure	PT-6860	PSIA	83	85	80	77
16	PTB Thrust Balance Pressure (AVG)	PT-6861A/B	PSIA	62	66	77	78
17	T25 H.P. Comp.Inlet Temp. (AVG)	TE-6837A/B	°F	229	207	188	206
18	T3 H.P.Comp. Temp. (AVG)	TE-6838A/B	°F	985	946	912	953
19	T4.8 L.P.Turbine Inlet Temp.	AVG	°F	1553	1547	1507	1582

20	Watt Meter		KW	30.7	31.7	30.3	30.283
21	Liquid Fuel Supply Flow		GPM	47	49	46	46
22	Liquid Fuel Supply Temperature		°F	108	109	110	109.1667
23	Liquid Fuel Supply Pressure		PSIG	1146	1132	1103	1125
24	NOx Water injection Flow Rate	FT-6243	GPM	17	16	22	20
25	VBV	ZE-6871	%	30	29	26	22
26	VSV	ZE-6873	%	77	78	79	78.5
27	Liquid Fuel Return Flow		GPM	1	1	1	1
28	VIGV	%		N/A	N/A	41	38
29	Naphtha Density	0.702		0.695	0.695	0.6995	0.702
30	Naphtha Temperature	29.8		30.5	30.5	33.4	29.8
31	Density at 15^0c	0.7154		0.7092	0.7092	0.7163	0.7154
32	Calorific Value	11326		11343	11343	11322.5	11326
33	Output	30.2833		30.7	31.7	30.3	30.2833
34	Net Fuel flow (Sup-Ret) (KL)	10.22		10.44	10.9	10.22	10.22
35	Density at Supply Temperature	0.69		0.69	0.684	0.69	0.69
36	**Heat Rate (kCal/kWh)**			2661.58	2667.79	2635.12	2637.38
	Gain in heat rate with VIGV for the two samples			26.46	30.40		

Average gain in Heat rate (kCal/kWh) 28.43

Implementation of S4 - upgraded software for control system of Gas Turbine # 1, 2, 3 for the reliability improvement

The control system software supplied by GE along with the Gas turbine Package during the year 1998 was started generating problems and giving spurious tripping. This affects the reliability of the running of Gas turbine. So after discussion with GE it was decided to upgrade the control system software. Accordingly GE published the Service bulletin for the S4 soft ware up gradation.

The software changes works were carried out in GT # 1, 2, 3 with a short note of advantages is as below,

S4 soft ware Block change - carried out in GT # 1, 2, 3

Objective

The main objective of this software modification is the Control system up gradation to improve reliability availability and maintainability by avoiding /minimizing the operation system trips generated due to spurious signals in the existing control system software. The details of improvement are mentioned under.

S.No.	Description	Advantages
1	Revised stall detection logic- correcting of false stall indications- reduces unnecessary boroscope inspections	New logic improves the discrimination between Stalls and flame out therefore prevents the false indication of stalls.
2	Revised flame detection logic-core speed threshold is used to Validate flame out above a certain load	A Secondary speed test has been added to validate flame detection signals. Core speed is used to validate flame detection condition. With the engine at max power, if both flame detectors fail with the combustor still lit, core speed will remain. This change delays the set of the Flame out latch until power is reduced below the core speed of 9500rpm. In the event of an actual flame out , speed will come down below the 9500rpm faster than the set delays. so flame out protection is not compromised. This increases the reliability and avoids tripping due to flame sensor failure.
3	Revised T48 spread logic.	The T48 spread value for trip - engine decel - to - min. has been increased to effectively eliminate the possibility of the

		engine decel - to - min due to T48 spread.T48 spread alarm is still configured and now Operator can decide to trouble shoot the T48 spread alarm and decide for the operating the machine. This avoids the tripping of engine due to one or two T48 sensor failure and subsequent increase of T48 spread.
4	Revised T3 regulator logic-	Stability margin has been improved to account for conditions when LHV is incorrectly adjusted to a lower than acutal value. This change improves the robustness and fault tolerance of the system.
5	Revised Variable geometry fault (Step ti Idle / shut down) Fault alarm logic	Present Logic-VBV: - (1) If position error is <9% average value is considered. (2) If position error is >10% -->SML, (3) If position error is between 9 & 10 , alarm and select the lower position value. A shut down action delay for 10 seconds has been added to any step to idle action due to VBV, VSV faults/alarms. This change eliminates the spurious tripping due toVBV & VSV faults.
6	Revised liq fuel flow reset logic- .	The Liquid fuel flow reset logic has been updated to manage fuel to air ratio and minimize LP Speed increase due to load thro off and load drop. This change reduces the trips due to over speed while avoiding flameouts.
7	Revised XNSD difference Alarm logic	LP rotor breakaway alarm is suppressed till XN25>8000rpm- thus eliminating nuisance alarm. This change increases the reliability of the operation.

The number of trips due to control system faults and spurious signal is reduced and there by the reliability of the machines improved, including fuel savings. The details of number of trips are mentioned below.

The comparison and advantages of the Plant reliability in operation, thus reduction in number of trips is as below.

Trips details	GT # 1	GT # 2	GT # 3
No. of trips from Oct 2003	39	48	30
No. of trips due to Control system fault	17	35	18
Control system fault trip after S4 soft ware change in July -2007 up to March 2008	0	1	1

Savings calculation

The cost of Software and other accessories: - U S $ 29924 /-

The Start up/Shut down fuel requirement: -

Requirement of Diesel and Naphtha or Start up of GTGs are as follows.

HSD : - 0.7 KL per Start up per GT

Naphtha : - 2.5 MT per Start up Per GT

Every start up of the unit consumes spare parts on GTGs to the extent of 8 to 12 hrs of its life costing for which works out for start up and shut down as follows

Cost of one start up = Rs 9, 15,000 /- per start up per GTG

Cost of Shut down = Rs 4, 07,500 / - per start up per GTG

The average number of tripping occurred due to control system problem from Oct 2003 to July 2007 as per the above chart = 20 Nos.

The cost of one shut down and start up is approximately – 13.225 lacs. The reductions in number of trips after the implementation of S4 software improves the reliability of the Gas turbine and reduces the cost of shut down and start up at the rate of Rs – 13.225 lacs.

CRT monitors replaced with TFT monitors for all Office computers in the Local Area Network of BKPL

CRT monitors – 39 nos in office network have been replaced with TFT monitors- 17 inch. size.

Power saving calculation is as below.

Rating of 17 inch size CRT monitors: - 73 watts

Rating of 17 inch size LCD monitors: - 30 watts

Considering an average operating hours of 10hours, the energy saving per monitor per day → (73 – 30) X 10 = 430wh

Total saving per day for 39 monitors --> 39 X 430 = 1.68kWh

Annual Savings in terms of number of units -→ (by taking average days of working per year as 275 days) = **462kWh**

Savings per year @ Rs 7.80 for the cost of fuel for generation = Rs 3604/-.