

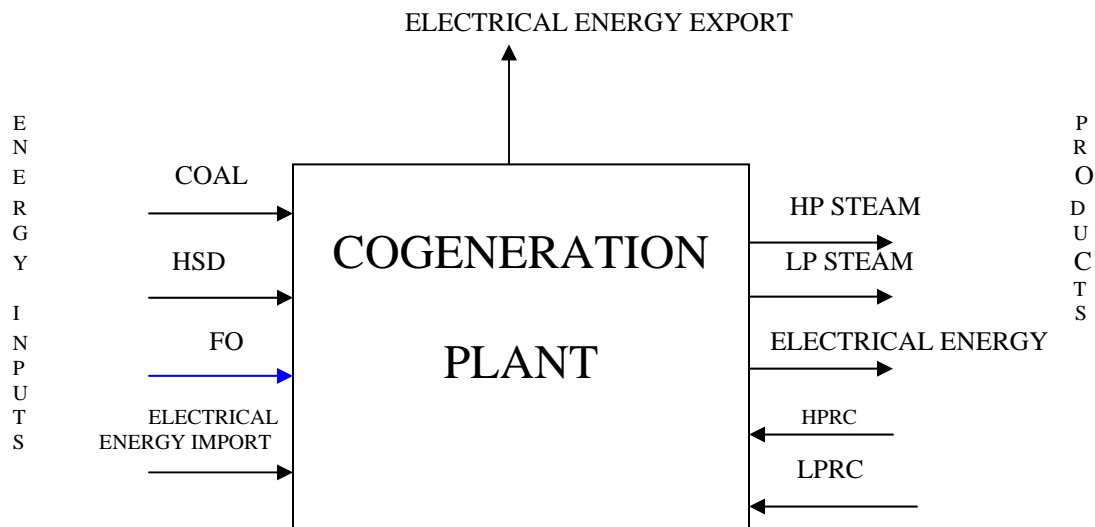
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TECHNICAL PAPER ON AGGREGATED DATA REPORTING

Data was collected from the cogeneration plant having coal fired boilers and double extraction condensing turbines which supply steam and electrical power to a process plant. The plant is connected to the state electricity grid so that electrical power can be imported / exported depending on the operating conditions. The plant uses HSD as a start up fuel, switching over to coal subsequently and furnace oil for load stabilization. Process plant, receives steam at two pressures namely HP steam at 32 kg/cm^2 & 240°C & LP steam at 8 kg/cm^2 & 178°C . Process plant after utilizing the latent heat of steam supplied returns back the condensate namely HP return condensate at 22 kg/cm^2 & 200°C and LP return condensate at around 1.5 kg/cm^2 & 120°C . Data was collected for last financial year i.e. from April 03 to March 04.

Based on the real data collected excel work sheets are developed to find the energy indicators namely cost of energy mix in Rs/Kwh, specific consumption in kwh/unit product mix & specific energy costs in Rs/unit product mix on monthly basis.

The boundary parameters used to arrive the energy indicators are shown below.



The products from cogeneration plant are taken as HP steam, LP steam and electrical energy. As some quantity of energy supplied is coming back as HPRC & LPRC, hence (HP steam supplied – HPRC), (LP steam supplied – LPRC) and electrical energy supplied to process plant including auxiliary power consumption are taken as products from the cogeneration plant. The total production is calculated in terms of Giga Calories by considering the enthalpies of steam and condensate. Instead of taking product as the final product of process plant, cogeneration products are considered as this gives clear picture of cogeneration plant energy indicators independent of process plant.

Energy consumption is calculated by considering the energy inputs i.e. coal, FO, HSD consumptions & electrical energy (import – export). All the energy inputs are converted in to common unit i.e. Kwh by considering the calorific values of coal, FO & HSD. By considering the costs of energy inputs the total cost of the energy consumed is also calculated. Based on these values the most vital energy indicators i.e. specific energy consumption & specific energy cost are found.

Following are the input data and formulas used to generate the energy indicators.

INPUT DATA:

- a) Monthly coal consumption in tons
- b) Monthly FO consumption in KL
- c) Monthly HSD consumption in KL
- d) Gross calorific value of coal in Kcal/kg (monthly average value)
- e) Gross calorific value of FO in Kcal/kg (monthly average value)
- f) Gross calorific value of HSD in Kcal/kg (monthly average value)
- g) Monthly average cost of coal in Rs/ton
- h) Monthly average cost of FO in Rs/Kl
- i) Monthly average cost of HSD in Rs/KL
- j) Electrical energy imported in kwh
- k) Electrical energy exported in kwh
- l) Unit cost of Electrical energy imported
- m) Unit cost of Electrical energy exported
- n) Monthly HP steam supplied to process plant in Tons
- o) Monthly LP steam supplied to process plant in Tons
- p) Monthly HPRC received back from process plant in Tons
- q) Monthly LPRC received back from process plant in Tons
- r) Electrical energy consumption of process plant in million units
- s) Electrical energy consumption of cogeneration plant in million units
- t) Enthalpy of HP steam supplied to process plant (monthly average value) in Kcal/kg
- u) Enthalpy of LP steam supplied to process plant (monthly average value) in Kcal/kg
- v) Enthalpy of HPRC received from process plant (monthly average value) in Kcal/kg
- w) Enthalpy of LPRC received from process plant (monthly average value) in Kcal/kg
- x) Monthly MD charges in Rs

DATA GENERATED FROM THE INPUT DATA:

- I) Total energy consumption in kwh

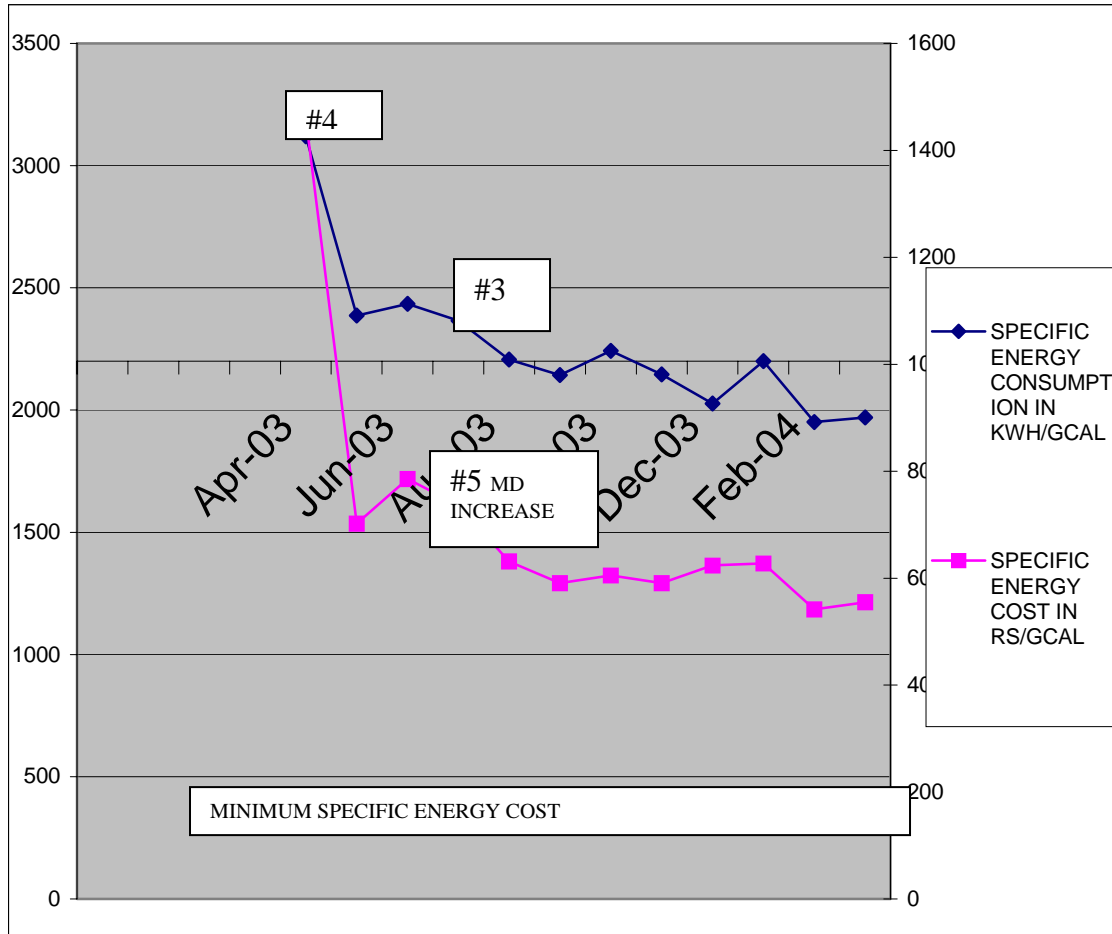
$$= (a * d + b * e + c * f)1000/860 + (j_k) \rightarrow A$$
- II) Total cost of energy consumed in Rs

$$= (a * g + b * h + c * I) + (j * l_k * m) + x \rightarrow B$$
- III) Cost of energy mix in Rs/ kwh = B/A
- IV) Total product mix in Gcal

$$= (n * t_p * v) / 1000 + (o * u_q * w) / 1000 + (r + s) * 860 \rightarrow C$$
- V) Specific energy consumption in Kwh/Gcal = A/C
- VI) Specific energy cost in Rs/Gcal = B/C

The detailed excel work sheets using the above formulas are inserted as Annexures – I, II, III & IV.

From the data obtained in Annexure IV the curves are developed to show the variation in monthly specific energy consumption and costs using Excel chart wizard. The graphical representation of the energy indicators is given below.



Based on the above graphical representation and with experience the following table is prepared for pop up explanations for change in consumption & costs. The peaks & valleys are labeled with pop up boxes stating the reasons from the above table.

TABLE-I
INCREASED SPECIFIC CONSUMPTION OR COST LIST

N O	Reason of increased energy consumption kwh /unit output i.e. Gcal	Reason of increased energy cost Rs /unit output i.e. Gcal
1	Increase in forced outages due to power plant	Fuel cost increased
2	Increase in forced outages due to process plant	Specific consumption increased
3	Increase in scheduled outages due to power plant	Revenue from diverted energy flow decreased
4	Increase in scheduled outages due to process plant	Cost of energy increased due to more import from the grid.
5	Poor coal quality	Cost of energy increased due to crossing of MD, hence paid penalty heavily.
6.	Increase in wastage of energy sources like coal, oil or steam leakages	Oil consumption increased due to continuous oil support due to poor coal quality/ part load operation of boilers.
7	More number of plant trips due to grid disturbances	Increase of electricity charges from grid due to poor power factor
8	Labour unrest	Increase in electricity charges by grid

TABLE-II
DECREASED SPECIFIC CONSUMPTION OR COST LIST

NO	Reason of decreased energy consumption kwh /unit output i.e. Gcal	Reason of decreased energy cost Rs /unit output i.e. Gcal
1	Decrease in forced outages due to power plant	Fuel cost decreased
2	Decrease in forced outages due to process plant	Specific consumption decreased
3	Decrease in scheduled outages due to power plant	Revenue from diverted energy flow increased
4	Decrease in scheduled outages due to process plant	Cost of energy decreased due to less import from the grid.
5	Good coal quality	Cost of energy decreased, as there is no crossing of MD.
6.	Reduction in wastage of energy sources like coal, oil or steam leakages	Oil consumption decreased, as there is no continuous oil support due to good coal quality/ full load operation of boilers.
7	Less number of plant trips due to grid disturbances	No Increase of electricity charges from grid as maintained power factor
8	No Labour unrest	Decrease in electricity charges by grid

Based on the previous performance values, the minimum specific energy consumption and minimum specific energy costs are taken as 2200 Kwh /Gca and .500 Rs/Gcal respectively. From these values monthly energy savings potential & monthly energy cost savings potential are calculated using the following formulas.

Monthly energy savings potential in Kwh

$$= (\text{Monthly specific energy consumption} - 2200) * \text{monthly production}$$

Monthly energy cost savings potential in Rs

$$= (\text{Monthly specific energy cost} - 500) * \text{monthly production}$$

Using the above monthly values are calculated in annexure IV and annual energy opportunity savings cost and lost opportunity for energy cost savings are calculated.

With reference to the qualitative rating of the energy conservation & energy efficiency measures mentioned in the issue the following are the observations.

1. Specific energy consumption and costs decrease whenever the planned or forced outages of the process plant and cogeneration are minimum i.e. Gold. Hence reducing the breakdowns of cogeneration plant & process plant should be aimed.
2. Specific energy consumption and energy costs increase whenever plant trips are more i.e. Red.
3. Hence shifting from red to gold can be achieved by adopting the policy “ Aim to reduce forced outages to minimum”
4. However by adopting the following energy conservation & energy efficiency measures specific energy consumption & energy cost reduction are possible
 - a) Replacing the motor driven BFPs with steam driven BFPs, incorporating variable speed drives to FD fans etc reduces the specific energy consumption and costs. Hence can be rated as Gold.
 - b) With agreement for more export of power to the grid, cost of production can be reduced as this leads to operating the plant at higher load factor. This can be rated as silver as the consumption increases but costs decreases.

Finally concluding this saying that every industry should aim to reach “Line of Zero percent loss “ by adopting suitable energy conservation and energy efficiency measures.

ANNEXURES I, II, III & IV

ANNEXURE- I

ENERGY CONSUMPTION (MONTHLY BASIS)

GCV OF COAL IN KCAL/Kg 4900
GCV OF FO IN KCAL/Kg 10100
GCV OF HSD IN KCAL/Kg 10300



MONTH & YEAR	COAL CONSUMPTION IN TONS	FO CONSUMPTION IN KL	HSD CONSUMPTION IN KL	COAL ENERGY CONSUMED IN KWH	FO ENERGY CONSUMED IN KWH	HSD ENERGY CONSUMED IN KWH	ELECTRICAL ENERGY IMPORTED IN KWH	ELECTRICAL ENERGY EXPORTED IN KWH	TOTAL ENERGY CONSUMPTION IN KWH
Apr-03	14543	829	86	82861279	9735930.2	1030000	1398000	252000	94773209.3
May-03	44647	577	0	254384070	6776395.3	0	136000	574000	260722465.1
Jun-03	39367	875	18	224300349	10276163	215581.4	246000	372000	234666093
Jul-03	44509	867	23	253597791	10182209	275465.12	176000	422000	263809465.1
Aug-03	46414	318	29	264451860	3734651.2	347325.58	190000	368000	268355837.2
Sep-03	41491	109	0	236402209	1280116.3	0	206000	400000	237488325.6
Oct-03	43769	7	0	249381512	82209.302	0	230000	434000	249259720.9
Nov-03	39962	88	10	227690465	1033488.4	119767.44	218000	452000	228609720.9
Dec-03	36580	479	90	208420930	5625465.1	1077907	286000	440000	214970302.3
Jan-04	42732	140	20	243473023	1644186	239534.88	194000	382000	245168744.2
Feb-04	38004	50	10	216534419	587209.3	119767.44	202000	64000	217379395.3
Mar-04	40649	135	21	231604767	1585465.1	251511.63	222000	116000	233547744.2

ANNEXURE-II

COST OF ENERGY MIX (MONTHLY BASIS)

COST OF COAL /TON IN Rs.	1500
COST OF FO/KL IN Rs.	15577
COST OF HSD/KL IN Rs.	23378
COST OF ELECTRICAL ENERGY IMPORT IN Rs	4.5
COST OF ELECTRICAL ENERGY EXPORT IN Rs.	2.5

MONTH & YEAR	COAL CONSUMED IN TONS	FO CONSUMED IN KL	HSD CONSUMED IN KL	ELECTRICAL ENERGY IMPORTED IN KWH	ELECTRICAL ENERGY EXPORTED IN KWH	COST OF COAL CONSUMED IN RS	COST OF FO CONSUMED IN RS	COST OF HSD CONSUMED IN RS	COST OF MD CHARGES	COST OF ELECTRICAL ENERGY IMPORTED IN RS	COST OF ELECTRICAL ENERGY EXPORTED IN RS	TOTAL COST OF ENERGY CONSUMED IN RS
Apr-03	14543	829	86	1398000	252000	21814500	12913333	2010508	1950000	6291000	630000	44349341
May-03	44647	577	0	136000	574000	66970500	8987929	0	1560000	612000	1435000	76695429
Jun-03	39367	875	18	246000	372000	59050500	13629875	420804	2418000	1107000	930000	75696179
Jul-03	44509	867	23	176000	422000	66763500	13505259	537694	1560000	792000	1055000	82103453
Aug-03	46414	318	29	190000	368000	69621000	4953486	677962	1560000	855000	920000	76747448
Sep-03	41491	109	0	206000	400000	62236500	1697893	0	1560000	927000	1000000	65421393
Oct-03	43769	7	0	230000	434000	65653500	109039	0	1560000	1035000	1085000	67272539
Nov-03	39962	88	10	218000	452000	59943000	1370776	233780	1560000	981000	1130000	62958556
Dec-03	36580	479	90	286000	440000	54870000	7461383	2104020	1560000	1287000	1100000	66182403
Jan-04	42732	140	20	194000	382000	64098000	2180780	467560	3237000	873000	955000	69901340
Feb-04	38004	50	10	202000	64000	57006000	778850	233780	1560000	909000	160000	60327630
Mar-04	40649	135	21	222000	116000	60973500	2102895	490938	1560000	999000	290000	65836333

ANNEXURE-III

PRODUCTION IN GIGA CALORIES (MONTHLY BASIS)

ENTHALPY OF HPRC STEAM IN KCAL/KG	235.3
ENTHALPY OF LPRC STEAM IN KCAL/KG	100
ENTHALPY OF HP STEAM IN KCAL/KG	672.4
ENTHALPY OF LP STEAM IN KCAL/KG	667.3

MONTH & YEAR	HP STEAM TO PROCESS PLANT IN TONS	LP STEAM TO PROCESS PLANT IN TONS	HPRC FROM PROCESS PLANT IN TONS	LPRC FROM PROCESS PLANT IN TONS	ELECTRICAL ENERGY TO PROCESS PLANT IN MU	IN HOUSE ELECTRICAL ENERGY CONSUMED IN MU	HP STEAM ENERGY SUPPLIED IN GCAL	LP STEAM ENERGY SUPPLIED IN GCAL	HPRC ENERGY RECEIVED IN GCAL	LPRC ENERGY RECEIVED IN GCAL	ELECTRICAL ENERGY SUPPLIED IN GCAL	IN HOUSE ELECTRICAL ENERGY IN GCAL	TOTAL ENERGY PRODUCTION IN GCAL
Apr-03	41798	4850	27360	1604	6.928	2.1437	28104.975	1070.349	6437.81	160.4	5958.08	1843.582	30378.7784
May-03	163058	8946	109368	2980	20.844	6.639	109640.2	1988.554	25734.3	298	17925.84	5709.54	109231.843
Jun-03	142647	11262	95760	3750	18.18	6.09975	95915.843	2502.375	22532.3	375	15634.8	5245.785	96391.4748
Jul-03	167737	14412	112344	4780	19.55	6.53475	112786.36	3189.694	26434.5	478	16813	5619.885	111496.395
Aug-03	184444	13617	127224	4534	22.18	6.8137	124020.15	3025.538	29935.8	453.4	19074.8	5859.782	121591.059
Sep-03	165678	12375	110880	4120	20.79	6.14655	111401.89	2749.276	26090.1	412	17879.4	5286.033	110814.532
Oct-03	166808	14135	115320	4707	20.932	6.36365	112161.7	3140.981	27134.8	470.7	18001.52	5472.739	111171.443
Nov-03	158916	14524	106560	4837	19.624	5.9908	106855.12	3227.73	25073.6	483.7	16876.64	5152.088	106554.309
Dec-03	159537	13936	110112	4640	19.592	6.0823	107272.68	3096.272	25909.4	464	16849.12	5230.778	106075.495
Jan-04	169874	14996	113832	4994	18.288	6.289	114223.28	3332.496	26784.7	499.4	15727.68	5408.54	111407.924
Feb-04	171633	13263	114840	4417	18.202	5.643	115406.03	2947.464	27021.9	441.7	15653.72	4852.98	111396.641
Mar-04	184108	12313	127224	4100	20.017	6.05365	123794.22	2735.93	29935.8	410	17214.62	5206.139	118605.101

ANNEXURE-4

ENERGY INDICATORS (MONTHLY BASIS)

MONTH & YEAR	TOTAL ENERGY CONSUMPTION IN KWH	TOTAL COST OF ENERGY CONSUMED IN Rs.	TOTAL ENERGY PRODUCTION IN GCAL	SPECIFIC ENERGY CONSUMPTION IN KWH/GCAL	SPECIFIC ENERGY COST IN RS/GCAL	MONTHLY ENERGY SAVINGS POTENTIAL IN KWH	MONTHLY ENERGY COST SAVINGS POTENTIAL IN RS	COGENERATION PLANT EFFICIENCY IN %
Apr-03	94773209.3	44349341	30378.7784	3119.717589	1459.879012	27939896.82	29159951.8	37.27230637
May-03	260722465.1	76695429	109231.8428	2386.872348	702.1343505	20412410.94	22079507.6	48.71608231
Jun-03	234666093	75696179	96391.4748	2434.510868	785.2995211	22604848.44	27500441.6	47.76280578
Jul-03	263809465.1	82103453	111496.3946	2366.08068	736.3776497	18517396.98	26355255.7	49.14416942
Aug-03	268355837.2	76747448	121591.0586	2207.035947	631.1931887	855508.28	15951918.7	52.68562567
Sep-03	237488325.6	65421393	110814.5322	2143.115356	590.3683542	-6303645.24	10014126.9	54.25702795
Oct-03	249259720.9	67272539	111171.4433	2242.12004	605.1242748	4682545.64	11686817.35	51.86121514
Nov-03	228609720.9	62958556	106554.3085	2145.476087	590.8588483	-5809757.8	9681401.75	54.19732732
Dec-03	214970302.3	66182403	106075.4952	2026.578352	623.9179263	-18395787.14	13144655.4	57.37704127
Jan-04	245168744.2	69901340	111407.9242	2200.640089	627.4359791	71310.96	14197377.9	52.83874922
Feb-04	217379395.3	60327630	111396.6413	1951.399905	541.5569922	-27693215.56	4629309.35	59.5875143
Mar-04	233547744.2	65836333	118605.101	1969.120571	555.0885455	-27383478	6533782.5	59.05126963

ANNUAL ENERGY SAVINGS COST OPPORTUNITY IN KWH
LOSS OPPORTUNITY FOR ENERGY COST SAVINGS IN RS

9498034.32
190934546.6