Table 8.1: Flow Duration Curve Results

Probability Exceedance (%)	Flow (m^3/s)	Probability Exceedance (%)	Flow (m^3/s)
10	613.4	60	44.3
20	376.6	70	36
30	205	80	30.3
40	103.3	90	26.2
50	61.3	99	20.5

8.2.2 Tail Water Rating Curve

In the Feasibility Study, tail-water rating curve for the downstream of Powerhouse was presented. However, the details of the calculations were not stated in the report such as manning coefficient assumed, which cross-section the calculations have been made on etc. The tailwater rating curve has been calculated during Review studies using HecRAS with cross sections from Feasibility study drawings and 2-3 m of difference has been obtained for all discharges. This might be due to the reason that the cross sectional information and other inputs are not know. Therefore, the difference in the results seems acceptable.

8.3 POWER AND ENERGY STUDIES

8.3.1 Net Head

Net design head in the Feasibility Report has been reported to vary between 105 m to 107 m. Review study revealed that the net head varies from 104.5 m to 106.5 m, therefore the results are significantly close to each other and acceptable at the feasibility stage.

The river discharge given in the 2nd period of July 1998 in Table 8-7 of the Feasibility Report is 832.02 m^3/s. 60 m^3/s part of this discharge is used for energy production in the power plant and the remaining 772.02 m^3/s is discharged through spillway. In this case, the water level elevation in the reservoir becomes approximately 2417.28 m according to our calculations. The water level for the same period in Figure 8-7 is 2416.80 m, which is close enough for the feasibility phase.

Tailwater water levels at various discharges given in Feasibility report Figure 8-8 coincide with the information given in Table 8.3. It has been determined that the information given in Section 8.5.2 (Table 8.3) of Feasibility report is sufficiently accurate and acceptable.

The tailwater channel width appears to be 45 m in the Powerhouse drawings. When the water height is calculated for 60 m^3/sec discharge in accordance with this width, the water depth above the crest is 0.85 m and the water level is 2298.85 m. In this case, it is understood that the water level of the stream bed (Feasibility Report Figure 8-8) dictates the tail water elevation and the net head calculations should be made accordingly.

8.3.2 Power and Energy Potential

Power and energy potential at the site have been estimated on average 10-daily basis using time series data from 1966 to 2015. Available head across the hydropower facility has been computed keeping in view the minimum and maximum operation water levels i.e. 2,012 to 2,014 m.a.s.l. Tailwater rating curve has been used for estimating the tailwater levels on the downstream side for determining the head available for power generation.

The power estimates have been computed by using the following formula and efficiency coefficients are given in Table 8.2.

$$P = \frac{\gamma x n x g x H x Q}{1000}$$

where,

P	=	Power output, 54 MW
ρ	=	Density of water, 1,000 kg /m^3
g	=	Gravity acceleration, 9.81 m/s^2
η	=	Overall efficiency of the hydroelectric plant 88.32%
Q	=	Design discharge, 60m3/s
H	=	Net Head varies between 105 m to 107.5 m depending head Water levels

Table 8.2: Efficiency Coefficients of Various Power Plant Components

Component	Efficiency
Turbine & Speed Increaser	91.5%
Generator	97.5%
Transformer	99%
Overall	88.32%

The average daily energy has been calculated as follows:

$$E = \frac{P \times h \times d}{1000}$$

where,

E	=	Energy output (GWh)
P	=	Power output (MW)
h	=	Hours in a day
d	=	Number of days in each time step

8.3.3 Optimization of Power and Energy

In previous studies (year 2017), 32.5 MW capacity plant had been proposed for this project, however, keeping in view the potential of the lake and availability of head, the power and energy optimization have been carried out to size the plant. Upstream water levels and tail water rating along with the average flow data for the period 1966 to 2015 have been used for calculating the power, energy and plant factor.

Comparison of power and energy potential of this study with the previous study has been tabulated in Table 8.3.

Table 8.3: Summary of Power & Energy Potential

Power and Energy Parameters	As in Previous Studies Conducted through Consultants	As in Feasibility Study, 2021, Conducted by WAPDA
Design Discharge (m^3/s)	40	60
Gross Head (m)	106	112
Power Capacity (MW)	32.5	54
Mean Annual Energy (GWh)	256.66	373.69
Plant Factor (%)	92.70	79

8.4 REVIEW STAGE CONFIRMATORY ENERGY CALCULATIONS

Review stage confirmatory energy calculations by MC have been done for three options for validation purpose.

a. With (02) No. Generating Units.
b. With (03) No. Generating Units.
c. With (04) No. Generating Units.

The detail calculations are presented in following sections.

8.4.1 Power and Energy Calculations based on Flow Duration Curve (FDC) method with Two (02) No. of Generating Units.

ATTABAD LAKE HYDROPOWER PROJECT

TABLE 8.1

POWER AND ENERGY CALCULATIONS

(FLOW DURATION CURVE METHOD)

Design Discharge	Q_D	=	**60.0**	m^3/sec
Environmental Flows	Q_E	=	**0.00**	m^3/sec
No. of Units		=	**2**	*FRANCIS*
Design Discharge (single unit)	Q_{unit}	=	**30.000**	m^3/sec
Gross Head	H_g	=	112.00	m
Head Loss	H_L	=	6.00	m
Net Head	H_n	=	**106.00**	m
Turbine Efficiency at Design Discharge	h_T	=	91.5%	
Generator Efficiency	h_G	=	96.6%	
Transformer Efficiency	h_{Tr}	=	98.0%	
Flushing Period	T_{FL}	=	10	days

GROSS POWER	**54.04**	**MW**
ANNUAL ENERG	**372.779**	**GWh**
PLANT FACTOR	**78.740**	**%**

TIME INCR.		PERIOD	FLOW DURATION	NET HEAD	TURBINE - 1				TURBINE - 2				Total Powe	ANNUAL ENERGY
					Q_1	h_{T1}	Power$_1$	Energy$_1$	Q_2	h_{T2}	Power$_2$	Energy$_2$	P=P1+P2 +P3+P4	Total
(Days)	(%)	(Days)	(m^3/s)	(m)	(m^3/s)	(%)	(MW)	(GWh)	(m^3/s)	(%)	(MW)	(GWh)	(MW)	(GWh)
1	0.3%	4	1567.123	106.0	30.000	93.3%	27.554	2.645	30.000	93.3%	27.554	2.645	55.108	5.290
5	1.4%	5	1436.616	106.0	30.000	93.3%	27.554	3.306	30.000	93.3%	27.554	3.306	55.108	6.613
10	2.7%	5	1271.233	106.0	30.000	93.3%	27.554	3.306	30.000	93.3%	27.554	3.306	55.108	6.613
15	4.1%	5	1106.849	106.0	30.000	93.3%	27.554	3.306	30.000	93.3%	27.554	3.306	55.108	6.613

TIME INCR.		PERIOD	FLOW DURATION	NET HEAD	TURBINE - 1				TURBINE - 2				Total Power	ANNUAL ENERGY
					Q_1	η_{T1}	$Power_1$	$Energy_1$	Q_2	η_{T2}	$Power_2$	$Energy_2$	P=P1+P2 +P3+P4	Total
(days)	(%)	(days)	(m^3/s)	(m)	(m^3/s)	(%)	(MW)	(GWh)	(m^3/s)	(%)	(MW)	(GWh)	(MW)	(GWh)
20	5.5%	5	962.929	106.0	30.000	93.3%	27.554	3.306	30.000	93.3%	27.554	3.306	55.108	6.613
25	6.8%	5	857.011	106.0	30.000	93.3%	27.554	3.306	30.000	93.3%	27.554	3.306	55.108	6.613
30	8.2%	5	751.093	106.0	30.000	93.3%	27.554	3.306	30.000	93.3%	27.554	3.306	55.108	6.613
35	9.6%	5	645.175	106.0	30.000	93.3%	27.554	3.306	30.000	93.3%	27.554	3.306	55.108	6.613
40	11.0%	5	590.693	106.0	30.000	93.3%	27.554	3.306	30.000	93.3%	27.554	3.306	55.108	6.613
45	12.3%	5	558.255	106.0	30.000	93.3%	27.554	3.306	30.000	93.3%	27.554	3.306	55.108	6.613
50	13.7%	5	525.816	106.0	30.000	93.3%	27.554	3.306	30.000	93.3%	27.554	3.306	55.108	6.613
55	15.1%	5	493.378	106.0	30.000	93.3%	27.554	3.306	30.000	93.3%	27.554	3.306	55.108	6.613
60	16.4%	5	460.940	106.0	30.000	93.3%	27.554	3.306	30.000	93.3%	27.554	3.306	55.108	6.613
65	17.8%	5	428.501	106.0	30.000	93.3%	27.554	3.306	30.000	93.3%	27.554	3.306	55.108	6.613
70	19.2%	5	396.063	106.0	30.000	93.3%	27.554	3.306	30.000	93.3%	27.554	3.306	55.108	6.613
75	20.5%	5	367.197	106.0	30.000	93.3%	27.554	3.306	30.000	93.3%	27.554	3.306	55.108	6.613
80	21.9%	5	343.690	106.0	30.000	93.3%	27.554	3.306	30.000	93.3%	27.554	3.306	55.108	6.613
85	23.3%	5	320.184	106.0	30.000	93.3%	27.554	3.306	30.000	93.3%	27.554	3.306	55.108	6.613
90	24.7%	5	296.677	106.0	30.000	93.3%	27.554	3.306	30.000	93.3%	27.554	3.306	55.108	6.613
95	26.0%	5	273.170	106.0	30.000	93.3%	27.554	3.306	30.000	93.3%	27.554	3.306	55.108	6.613
100	27.4%	5	249.663	106.0	30.000	93.3%	27.554	3.306	30.000	93.3%	27.554	3.306	55.108	6.613
105	28.8%	5	226.156	106.0	30.000	93.3%	27.554	3.306	30.000	93.3%	27.554	3.306	55.108	6.613
110	30.1%	5	203.807	106.0	30.000	93.3%	27.554	3.306	30.000	93.3%	27.554	3.306	55.108	6.613
115	31.5%	5	189.675	106.0	30.000	93.3%	27.554	3.306	30.000	93.3%	27.554	3.306	55.108	6.613
120	32.9%	5	175.744	106.0	30.000	93.3%	27.554	3.306	30.000	93.3%	27.554	3.306	55.108	6.613

TIME INCR.		PERIOD	FLOW DURATION	NET HEAD	TURBINE - 1				TURBINE - 2				Total Power	ANNUAL ENERGY
					Q_1	η_{T1}	$Power_1$	$Energy_1$	Q_2	η_{T2}	$Power_2$	$Energy_2$	P=P1+P2 +P3+P4	Total
(Days)	(%)	(Days)	(m^3/s)	(m)	(m^3/s)	(%)	(MW)	(GWh)	(m^3/s)	(%)	(MW)	(GWh)	(MW)	(GWh)
125	34.2%	5	161.812	106.0	30.000	93.3%	27.554	3.306	30.000	93.3%	27.554	3.306	55.108	6.613
130	35.6%	5	147.881	106.0	30.000	93.3%	27.554	3.306	30.000	93.3%	27.554	3.306	55.108	6.613
135	37.0%	5	133.949	106.0	30.000	93.3%	27.554	3.306	30.000	93.3%	27.554	3.306	55.108	6.613
140	38.4%	5	120.018	106.0	30.000	93.3%	27.554	3.306	30.000	93.3%	27.554	3.306	55.108	6.613
145	39.7%	5	106.086	106.0	30.000	93.3%	27.554	3.306	30.000	93.3%	27.554	3.306	55.108	6.613
150	41.1%	5	98.697	106.0	30.000	93.3%	27.554	3.306	30.000	93.3%	27.554	3.306	55.108	6.613
155	42.5%	5	92.944	106.0	30.000	93.3%	27.554	3.306	30.000	93.3%	27.554	3.306	55.108	6.613
160	43.8%	5	87.190	106.0	30.000	93.3%	27.554	3.306	30.000	93.3%	27.554	3.306	55.108	6.613
165	45.2%	5	81.437	106.0	30.000	93.3%	27.554	3.306	30.000	93.3%	27.554	3.306	55.108	6.613
170	46.6%	5	75.684	106.0	30.000	93.3%	27.554	3.306	30.000	93.3%	27.554	3.306	55.108	6.613
175	47.9%	5	69.930	106.0	30.000	93.3%	27.554	3.306	30.000	93.3%	27.554	3.306	55.108	6.613
180	49.3%	5	64.177	106.0	30.000	93.3%	27.554	3.306	30.000	93.3%	27.554	3.306	55.108	6.613
185	50.7%	5	60.136	106.0	30.000	93.3%	27.554	3.306	30.000	93.3%	27.554	3.306	55.108	6.613
190	52.1%	5	57.807	106.0	28.903	93.5%	26.592	3.191	28.903	93.5%	26.592	3.191	53.185	6.382
195	53.4%	5	55.478	106.0	27.739	93.6%	25.568	3.068	27.739	93.6%	25.568	3.068	51.135	6.136
200	54.8%	5	53.149	106.0	26.575	93.5%	24.463	2.936	26.575	93.5%	24.463	2.936	48.926	5.871
205	56.2%	5	50.821	106.0	25.410	93.2%	23.312	2.797	25.410	93.2%	23.312	2.797	46.623	5.595
210	57.5%	5	48.492	106.0	24.246	92.9%	22.168	2.660	24.246	92.9%	22.168	2.660	44.335	5.320
215	58.9%	5	46.163	106.0	23.082	92.6%	21.031	2.524	23.082	92.6%	21.031	2.524	42.062	5.047
220	60.3%	5	44.073	106.0	22.036	91.8%	19.911	2.389	22.036	91.8%	19.911	2.389	39.823	4.779
225	61.6%	5	42.936	106.0	21.468	91.0%	19.239	2.309	21.468	91.0%	19.239	2.309	38.478	4.617

TIME INCR.		PERIOD	FLOW DURATION	NET HEAD	TURBINE - 1				TURBINE - 2				Total Power	ANNUAL ENERGY
					Q_1	η_{T1}	$Power_1$	$Energy_1$	Q_2	η_{T2}	$Power_2$	$Energy_2$	P=P1+P2 +P3+P4	Total
(days)	(%)	(days)	(m^3/s)	(m)	(m^3/s)	(%)	(MW)	(GWh)	(m^3/s)	(%)	(MW)	(GWh)	(MW)	(GWh)
230	63.0%	5	41.799	106.0	20.899	90.3%	18.575	2.229	20.899	90.3%	18.575	2.229	37.151	4.458
235	64.4%	5	40.662	106.0	20.331	89.5%	17.920	2.150	20.331	89.5%	17.920	2.150	35.840	4.301
240	65.8%	5	39.525	106.0	19.762	88.8%	17.273	2.073	19.762	88.8%	17.273	2.073	34.546	4.145
245	67.1%	5	38.388	106.0	19.194	88.0%	16.634	1.996	19.194	88.0%	16.634	1.996	33.268	3.992
250	68.5%	5	37.251	106.0	18.625	87.3%	16.004	1.920	18.625	87.3%	16.004	1.920	32.008	3.841
255	69.9%	5	36.114	106.0	18.057	86.5%	15.382	1.846	18.057	86.5%	15.382	1.846	30.764	3.692
260	71.2%	5	35.297	106.0	17.649	86.0%	14.941	1.793	17.649	86.0%	14.941	1.793	29.881	3.586
265	72.6%	5	34.516	106.0	17.258	85.5%	14.523	1.743	17.258	85.5%	14.523	1.743	29.045	3.485
270	74.0%	5	33.736	106.0	16.868	85.0%	14.108	1.693	16.868	85.0%	14.108	1.693	28.217	3.386
275	75.3%	5	32.955	106.0	16.477	84.5%	13.698	1.644	16.477	84.5%	13.698	1.644	27.397	3.288
280	76.7%	5	32.174	106.0	16.087	83.9%	13.292	1.595	16.087	83.9%	13.292	1.595	26.584	3.190
285	78.1%	5	31.393	106.0	15.697	83.4%	12.890	1.547	15.697	83.4%	12.890	1.547	25.780	3.094
290	79.5%	5	30.612	106.0	15.306	82.9%	12.492	1.499	15.306	82.9%	12.492	1.499	24.983	2.998
295	80.8%	5	29.953	106.0	29.963	93.3%	27.521	3.303	0.000	0.0%	0.000	0.000	27.521	3.303
300	82.2%	5	29.401	106.0	29.401	93.4%	27.029	3.244	0.000	0.0%	0.000	0.000	27.029	3.244
305	83.6%	5	28.840	106.0	28.840	93.5%	26.536	3.184	0.000	0.0%	0.000	0.000	26.536	3.184
310	84.9%	5	28.278	106.0	28.278	93.6%	26.042	3.125	0.000	0.0%	0.000	0.000	26.042	3.125
315	86.3%	5	27.716	106.0	27.716	93.6%	25.548	3.066	0.000	0.0%	0.000	0.000	25.548	3.066
320	87.7%	5	27.155	106.0	27.155	93.7%	25.039	3.005	0.000	0.0%	0.000	0.000	25.039	3.005
325	89.0%	5	26.593	106.0	26.593	93.5%	24.481	2.938	0.000	0.0%	0.000	0.000	24.481	2.938
330	90.4%	5	25.966	106.0	25.966	93.3%	23.860	2.863	0.000	0.0%	0.000	0.000	23.860	2.863

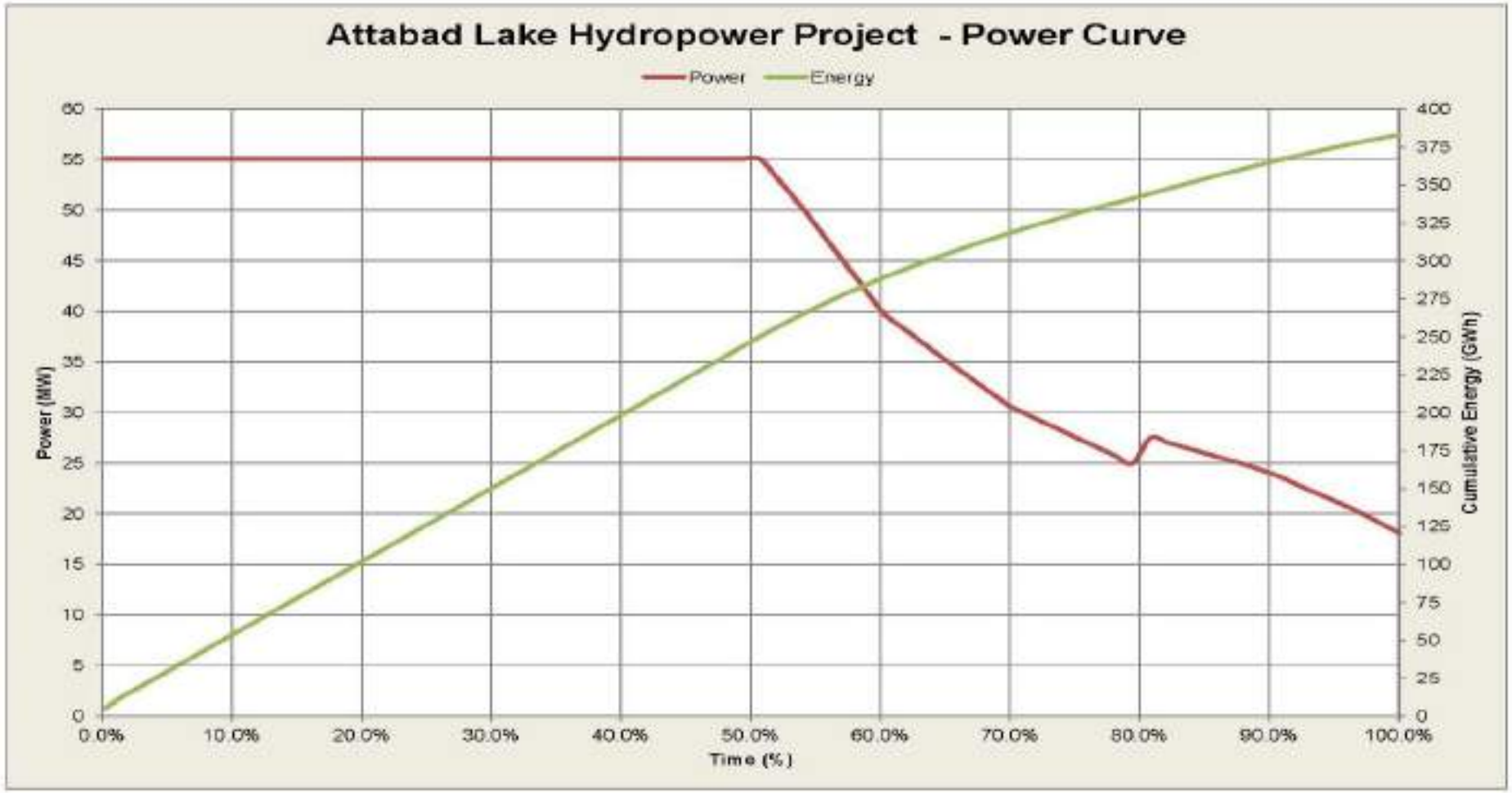
TIME INCR.		PERIOD	FLOW DURATION	NET HEAD	TURBINE - 1				TURBINE - 2				Total Power	ANNUAL ENERGY
					Q_1	η_{T1}	$Power_1$	$Energy_1$	Q_2	η_{T2}	$Power_2$	$Energy_2$	P=P1+P2 +P3+P4	Total
(days)	(%)	(days)	(m^3/s)	(m)	(m^3/s)	(%)	(MW)	(GWh)	(m^3/s)	(%)	(MW)	(GWh)	(MW)	(GWh)
335	91.8%	5	25.185	106.0	25.185	93.1%	23.090	2.771	0.000	0.0%	0.000	0.000	23.090	2.771
340	93.2%	5	24.404	106.0	24.404	92.9%	22.323	2.679	0.000	0.0%	0.000	0.000	22.323	2.679
345	94.5%	5	23.623	106.0	23.623	92.7%	21.559	2.587	0.000	0.0%	0.000	0.000	21.559	2.587
350	95.9%	5	22.842	106.0	22.842	92.5%	20.798	2.496	0.000	0.0%	0.000	0.000	20.798	2.496
355	97.3%	5	22.062	106.0	22.062	91.8%	19.942	2.393	0.000	0.0%	0.000	0.000	19.942	2.393
360	98.6%	5	21.281	106.0	21.281	90.8%	19.020	2.282	0.000	0.0%	0.000	0.000	19.020	2.282
365	100.0%	5	20.500	106.0	20.500	89.8%	18.114	2.174	0.000	0.0%	0.000	0.000	18.114	2.174
MEAN ANNUAL ENERGY (GWh)								=						**383.28**

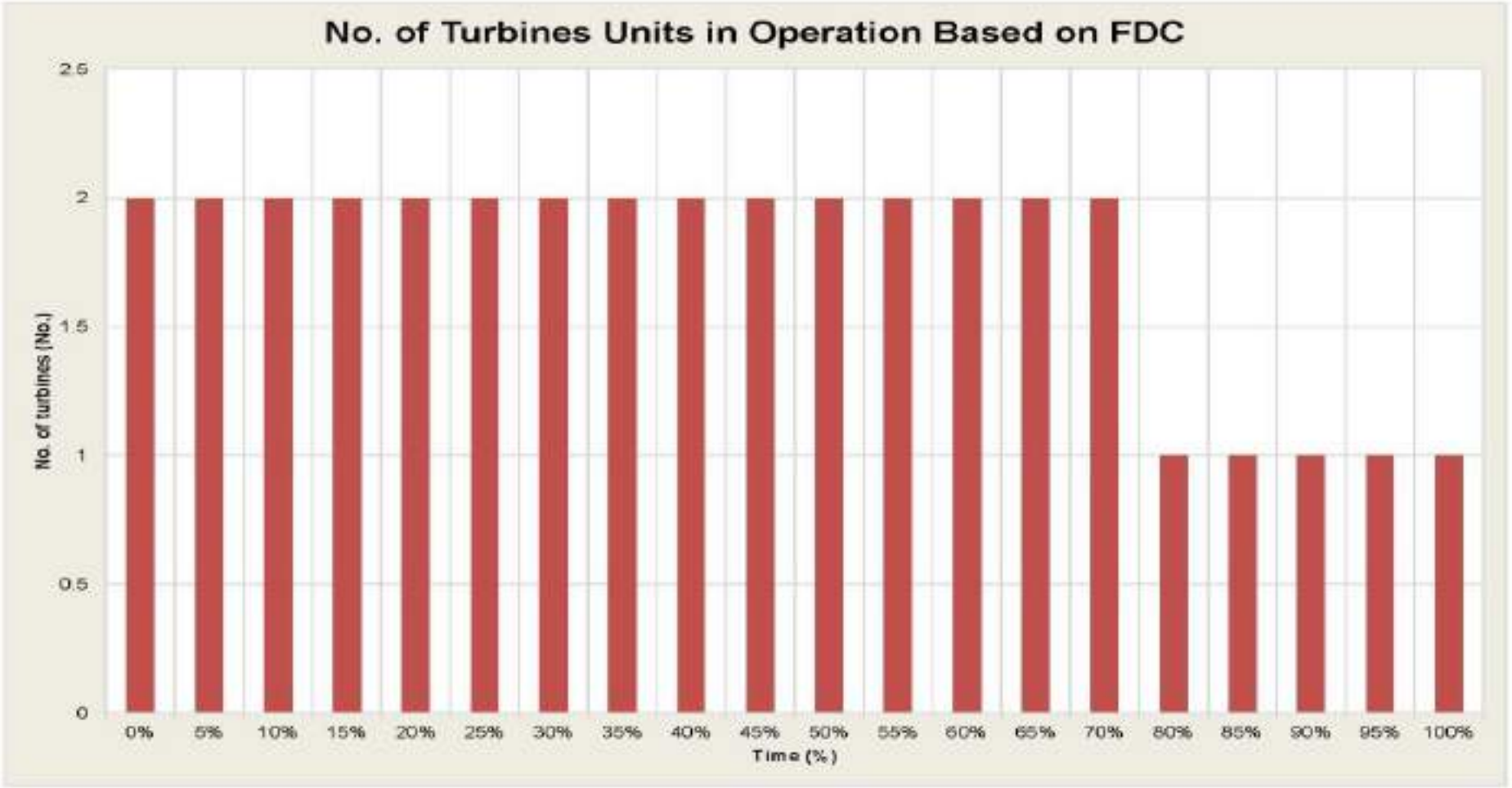
Annual Downtime Losses 10 days closure) = 2.74%

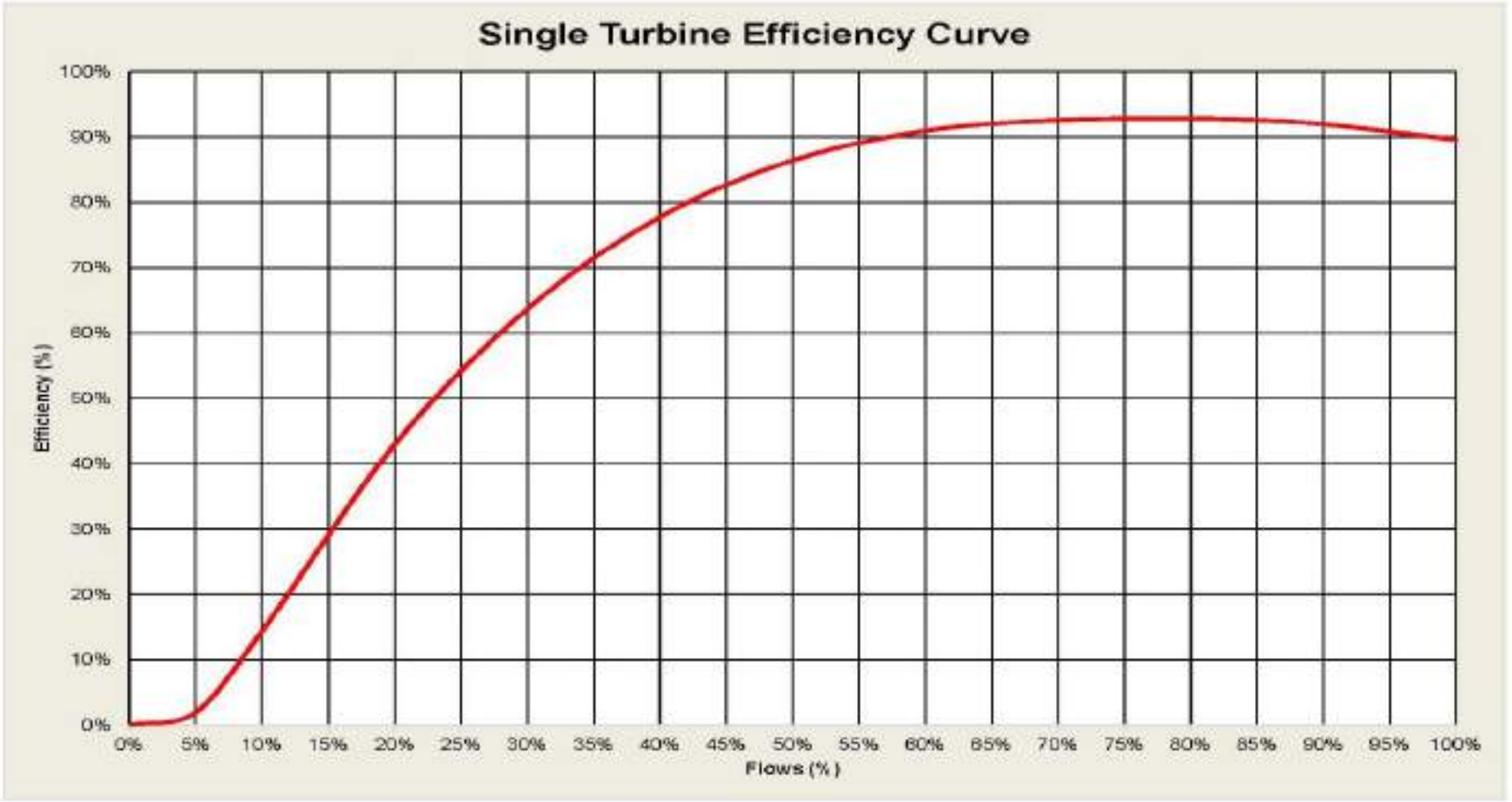
Actual Mean Annual Energy (GWh) = **372.8**

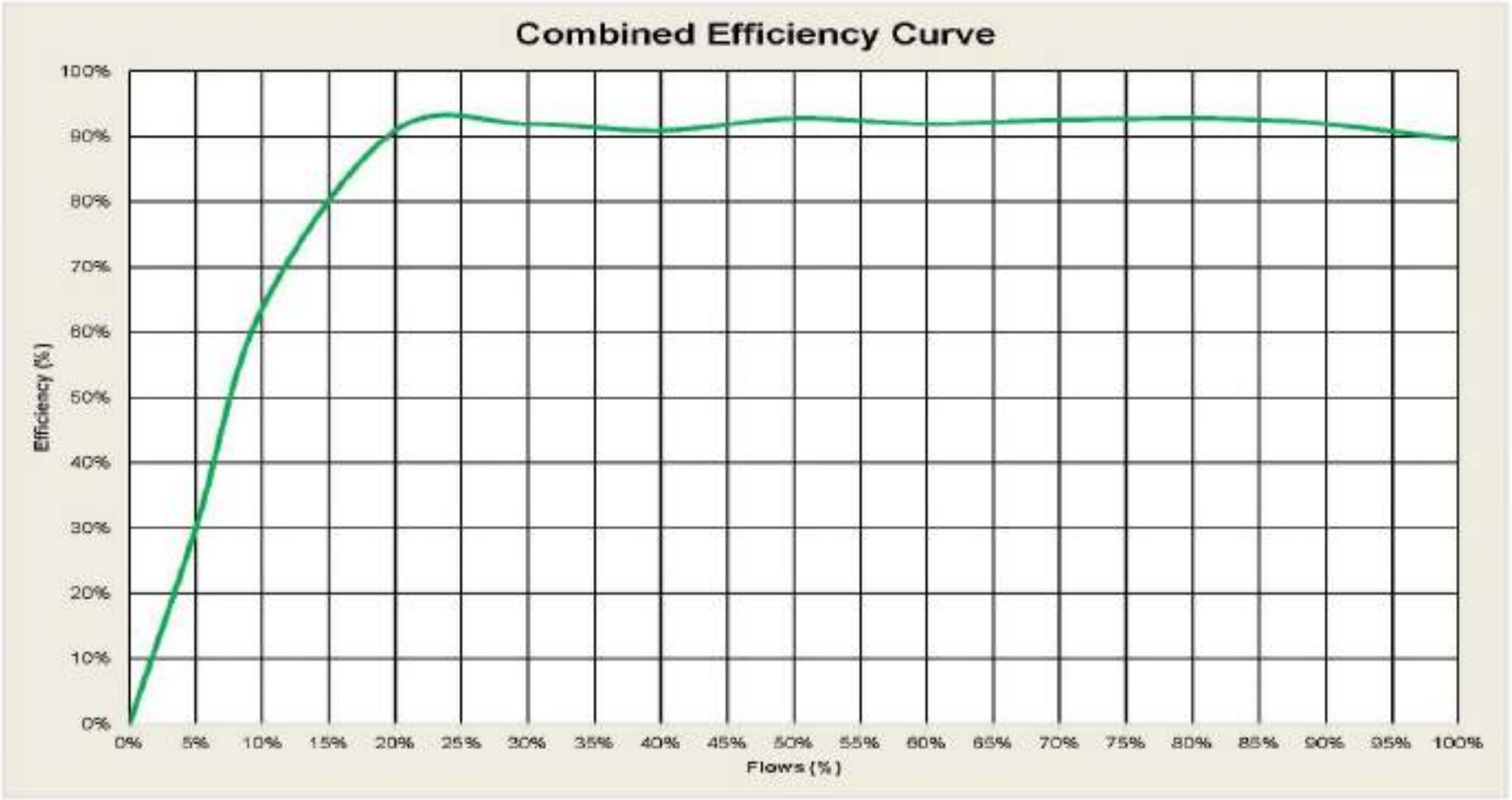
$$\text{Plant Factor} = \frac{372.8 \times 10^6}{54.04 \times 8760000} = \frac{\text{Actual Energy}}{\text{Theoretical Energy}}$$

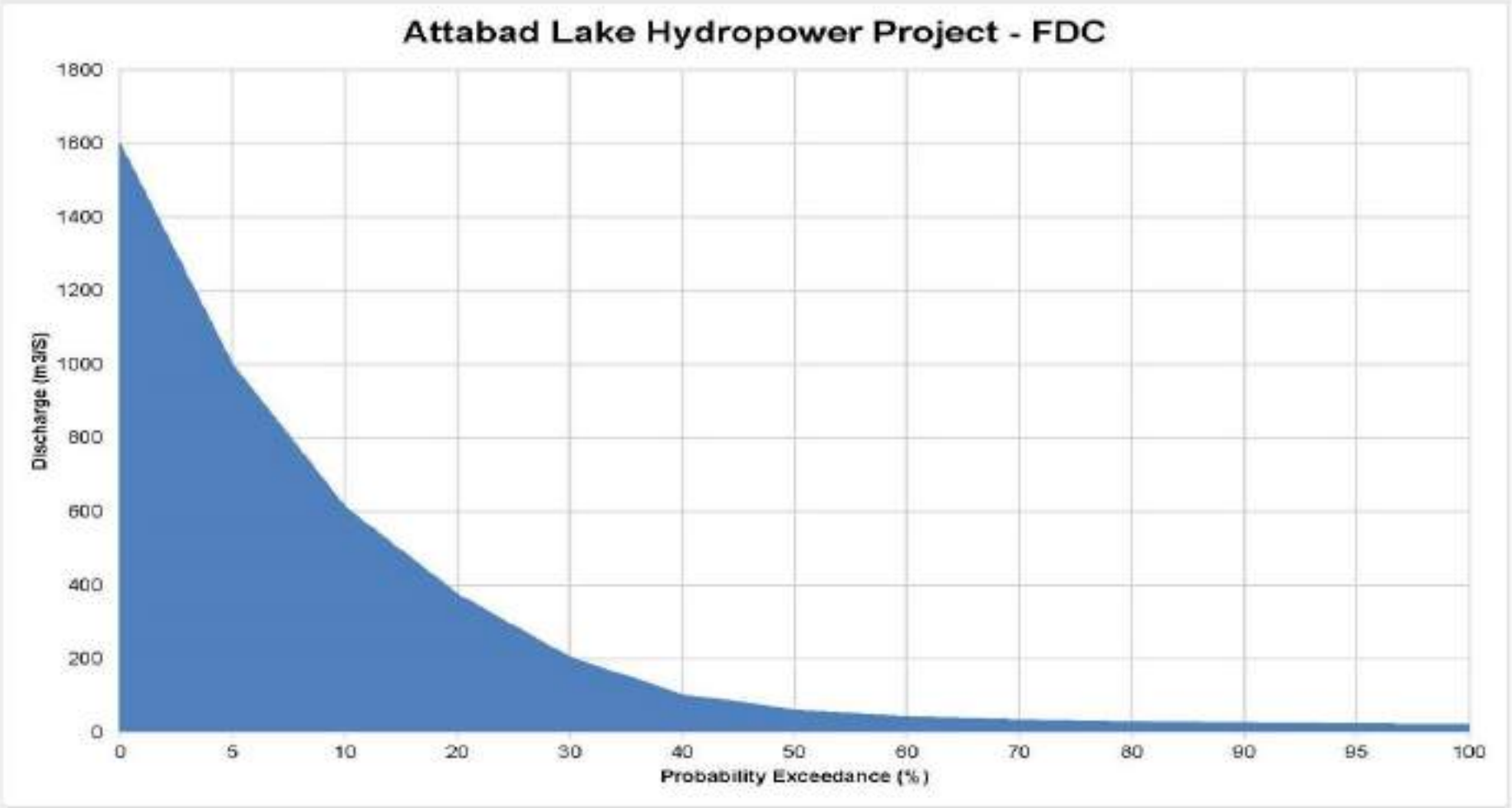
Plant Factor = **78.74%**

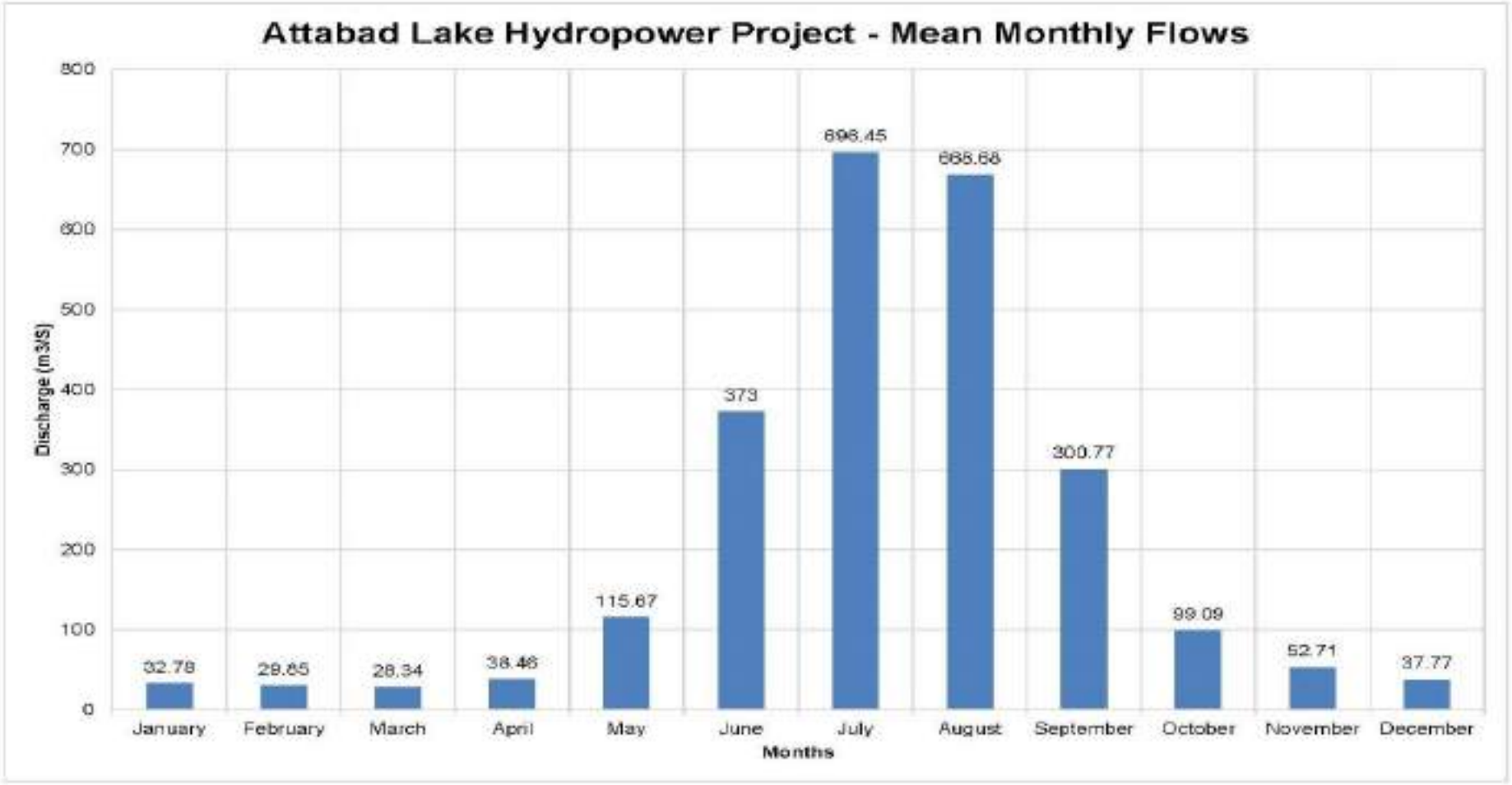

Attabad Lake Hydropower Project - Power Curve
Power
Energy
Power (MW)
Cumulative Energy (GWh)
Time (%)
0
5
10
15
20
25
30
35
40
45
50
55
60
0
25
50
75
100
125
150
175
200
225
250
275
300
325
350
375
400
0.0%
10.0%
20.0%
30.0%
40.0%
50.0%
60.0%
70.0%
80.0%
90.0%
100.0%


No. of Turbines Units in Operation Based on FDC
No. of turbines (No.)
2.5
2
1.5
1
0.5
0
0%
5%
10%
15%
20%
25%
30%
35%
40%
45%
50%
55%
60%
65%
70%
80%
85%
90%
95%
100%
Time (%)


Single Turbine Efficiency Curve
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
Efficiency (%)
0%
5%
10%
15%
20%
25%
30%
35%
40%
45%
50%
55%
60%
65%
70%
75%
80%
85%
90%
95%
100%
Flows (%)


Combined Efficiency Curve
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
Efficiency (%)
0%
5%
10%
15%
20%
25%
30%
35%
40%
45%
50%
55%
60%
65%
70%
75%
80%
85%
90%
95%
100%
Flows (%)


Attabad Lake Hydropower Project - FDC
Discharge (m3/S)
1800
1600
1400
1200
1000
800
600
400
200
0
0
5
10
20
30
40
50
60
70
80
90
95
100
Probability Exceedance (%)


Attabad Lake Hydropower Project - Mean Monthly Flows
Discharge (m3/S)
800
700
600
500
400
300
200
100
0
32.78
29.65
28.34
38.46
115.67
373
696.45
665.68
300.77
99.09
52.71
37.77
January
February
March
April
May
June
July
August
September
October
November
December
Months

8.4.2 Power and Energy Calculations based on Flow Duration Curve (FDC) method with Three (03) No. of Generating Units

Sheet 1 of 4

ATTABAD LAKE HYDROPOWER PROJECT

TABLE 8.2

POWER AND ENERGY CALCULATIONS

(FLOW DURATION CURVE METHOD)

Design Discharge	Q_D	=	60.0	m^3/sec
Environmental Flows	Q_E	=	0.00	m^3/sec
No. of Units		=	3	FRANCIS
Design Discharge (single unit)	Q_{unit}	=	20.000	m^3/sec
Gross Head	H_g	=	112.00	m
Head Loss	H_L	=	6.00	m
Net Head	H_n	=	106.00	m
Turbine Efficiency at Design Discharge	h_T	=	91.5%	
Generator Efficiency	h_G	=	96.6%	
Transformer Efficiency	h_{TR}	=	98.0%	
Flushing Period	T_{FL}	=	10	days

GROSS POWER	54.04	MW
ANNUAL ENERGY	374.06	GWh
PLANT FACTOR	79.011	%

TIME INCR.		PERIOD	FLOW DURATION	NET HEAD	TURBINE - 1				TURBINE - 2				TURBINE - 3				Total Power	ANNUAL ENERGY
					Q_1	h_T	Power	Energy	Q_2	h_T	Power	Energy	Q_3	h_T	Power	Energy	(P=P1+P2+P3+P4)	Total
days	(%)	days	m^3/s	(m)	(m^3/s)	(%)	(MW)	(MWh)	(m^3/s)	(%)	(MW)	(MWh)	(m^3/s)	(%)	(MW)	(MWh)	(MW)	(MWh)
1	0.3%	4	1567.123	106.0	20.000	93.3%	18.369	1.763	20.000	93.3%	18.369	1.763	20.000	93.3%	18.369	1.763	55.108	5.290
5	1.4%	5	1436.616	106.0	20.000	93.3%	18.369	2.204	20.000	93.3%	18.369	2.204	20.000	93.3%	18.369	2.204	55.108	6.613
10	2.7%	5	1271.233	106.0	20.000	93.3%	18.369	2.204	20.000	93.3%	18.369	2.204	20.000	93.3%	18.369	2.204	55.108	6.613
15	4.1%	5	1106.849	106.0	20.000	93.3%	18.369	2.204	20.000	93.3%	18.369	2.204	20.000	93.3%	18.369	2.204	55.108	6.613
20	5.5%	5	982.929	106.0	20.000	93.3%	18.369	2.204	20.000	93.3%	18.369	2.204	20.000	93.3%	18.369	2.204	55.108	6.613
25	6.8%	5	857.011	106.0	20.000	93.3%	18.369	2.204	20.000	93.3%	18.369	2.204	20.000	93.3%	18.369	2.204	55.108	6.613
30	8.2%	5	751.068	106.0	20.000	93.3%	18.369	2.204	20.000	93.3%	18.369	2.204	20.000	93.3%	18.369	2.204	55.108	6.613
35	9.6%	5	645.175	106.0	20.000	93.3%	18.369	2.204	20.000	93.3%	18.369	2.204	20.000	93.3%	18.369	2.204	55.108	6.613
40	11.0%	5	590.693	106.0	20.000	93.3%	18.369	2.204	20.000	93.3%	18.369	2.204	20.000	93.3%	18.369	2.204	55.108	6.613
45	12.3%	5	559.255	106.0	20.000	93.3%	18.369	2.204	20.000	93.3%	18.369	2.204	20.000	93.3%	18.369	2.204	55.108	6.613

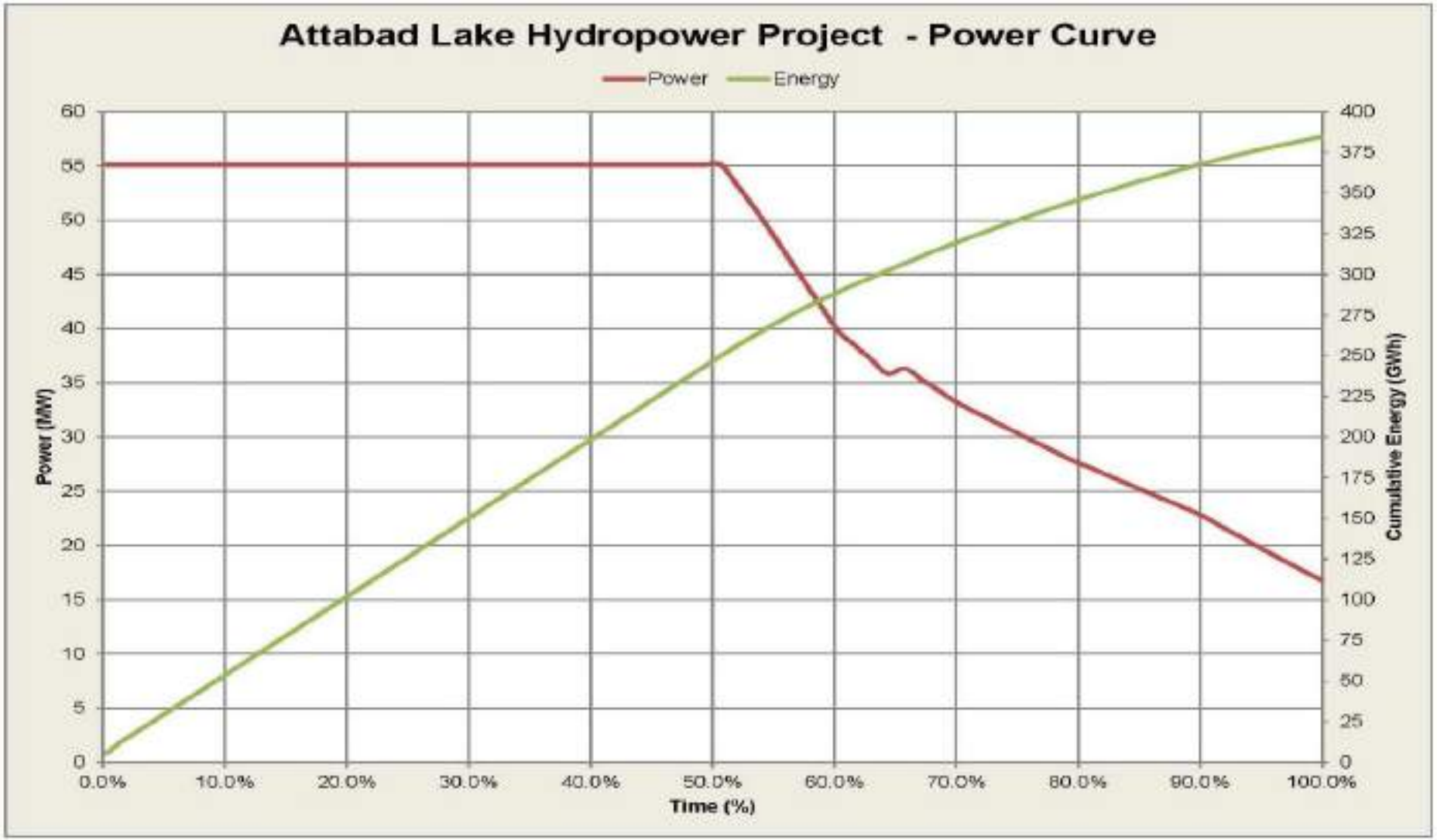
TIME INCR.		PERIOD	FLOW DURATION	NET HEAD	TURBINE - 1				TURBINE - 2				TURBINE - 3				Total Power	ANNUAL ENERGY
					Q_1	η_1	$Power_1$	$Energy_1$	Q_2	η_2	$Power_2$	$Energy_2$	Q_3	η_3	$Power_3$	$Energy_3$	$P=P_1+P_2+P_3$	Total
(days)	(%)	(days)	(m^3/s)	(m)	(m^3/s)	(%)	(MW)	(GWH)	(m^3/s)	(%)	(MW)	(GWH)	(m^3/s)	(%)	(MW)	(GWH)	(MW)	(GWH)
50	13.7%	5	525.816	106.0	20.000	93.3%	18.369	2.204	20.000	93.3%	18.369	2.204	20.000	93.3%	18.369	2.204	55.108	6.613
55	15.1%	5	493.378	106.0	20.000	93.3%	18.369	2.204	20.000	93.3%	18.369	2.204	20.000	93.3%	18.369	2.204	55.108	6.613
60	16.4%	5	460.840	106.0	20.000	93.3%	18.369	2.204	20.000	93.3%	18.369	2.204	20.000	93.3%	18.369	2.204	55.108	6.613
65	17.8%	5	428.501	106.0	20.000	93.3%	18.369	2.204	20.000	93.3%	18.369	2.204	20.000	93.3%	18.369	2.204	55.108	6.613
70	19.2%	5	396.063	106.0	20.000	93.3%	18.369	2.204	20.000	93.3%	18.369	2.204	20.000	93.3%	18.369	2.204	55.108	6.613
75	20.5%	5	367.197	106.0	20.000	93.3%	18.369	2.204	20.000	93.3%	18.369	2.204	20.000	93.3%	18.369	2.204	55.108	6.613
80	21.8%	5	343.690	106.0	20.000	93.3%	18.369	2.204	20.000	93.3%	18.369	2.204	20.000	93.3%	18.369	2.204	55.108	6.613
85	23.3%	5	320.184	106.0	20.000	93.3%	18.369	2.204	20.000	93.3%	18.369	2.204	20.000	93.3%	18.369	2.204	55.108	6.613
90	24.7%	5	296.677	106.0	20.000	93.3%	18.369	2.204	20.000	93.3%	18.369	2.204	20.000	93.3%	18.369	2.204	55.108	6.613
95	26.0%	5	273.170	106.0	20.000	93.3%	18.369	2.204	20.000	93.3%	18.369	2.204	20.000	93.3%	18.369	2.204	55.108	6.613
100	27.4%	5	249.663	106.0	20.000	93.3%	18.369	2.204	20.000	93.3%	18.369	2.204	20.000	93.3%	18.369	2.204	55.108	6.613
105	28.8%	5	226.156	106.0	20.000	93.3%	18.369	2.204	20.000	93.3%	18.369	2.204	20.000	93.3%	18.369	2.204	55.108	6.613
110	30.1%	5	203.607	106.0	20.000	93.3%	18.369	2.204	20.000	93.3%	18.369	2.204	20.000	93.3%	18.369	2.204	55.108	6.613
115	31.5%	5	189.675	106.0	20.000	93.3%	18.369	2.204	20.000	93.3%	18.369	2.204	20.000	93.3%	18.369	2.204	55.108	6.613
120	32.8%	5	175.744	106.0	20.000	93.3%	18.369	2.204	20.000	93.3%	18.369	2.204	20.000	93.3%	18.369	2.204	55.108	6.613
125	34.2%	5	161.812	106.0	20.000	93.3%	18.369	2.204	20.000	93.3%	18.369	2.204	20.000	93.3%	18.369	2.204	55.108	6.613
130	35.6%	5	147.881	106.0	20.000	93.3%	18.369	2.204	20.000	93.3%	18.369	2.204	20.000	93.3%	18.369	2.204	55.108	6.613
135	37.0%	5	133.949	106.0	20.000	93.3%	18.369	2.204	20.000	93.3%	18.369	2.204	20.000	93.3%	18.369	2.204	55.108	6.613
140	38.4%	5	120.018	106.0	20.000	93.3%	18.369	2.204	20.000	93.3%	18.369	2.204	20.000	93.3%	18.369	2.204	55.108	6.613
145	39.7%	5	106.086	106.0	20.000	93.3%	18.369	2.204	20.000	93.3%	18.369	2.204	20.000	93.3%	18.369	2.204	55.108	6.613
150	41.1%	5	98.697	106.0	20.000	93.3%	18.369	2.204	20.000	93.3%	18.369	2.204	20.000	93.3%	18.369	2.204	55.108	6.613
155	42.5%	5	92.964	106.0	20.000	93.3%	18.369	2.204	20.000	93.3%	18.369	2.204	20.000	93.3%	18.369	2.204	55.108	6.613
160	43.8%	5	87.190	106.0	20.000	93.3%	18.369	2.204	20.000	93.3%	18.369	2.204	20.000	93.3%	18.369	2.204	55.108	6.613
165	45.2%	5	81.437	106.0	20.000	93.3%	18.369	2.204	20.000	93.3%	18.369	2.204	20.000	93.3%	18.369	2.204	55.108	6.613
170	46.6%	5	75.684	106.0	20.000	93.3%	18.369	2.204	20.000	93.3%	18.369	2.204	20.000	93.3%	18.369	2.204	55.108	6.613
175	47.9%	5	69.930	106.0	20.000	93.3%	18.369	2.204	20.000	93.3%	18.369	2.204	20.000	93.3%	18.369	2.204	55.108	6.613
180	49.3%	5	64.177	106.0	20.000	93.3%	18.369	2.204	20.000	93.3%	18.369	2.204	20.000	93.3%	18.369	2.204	55.108	6.613

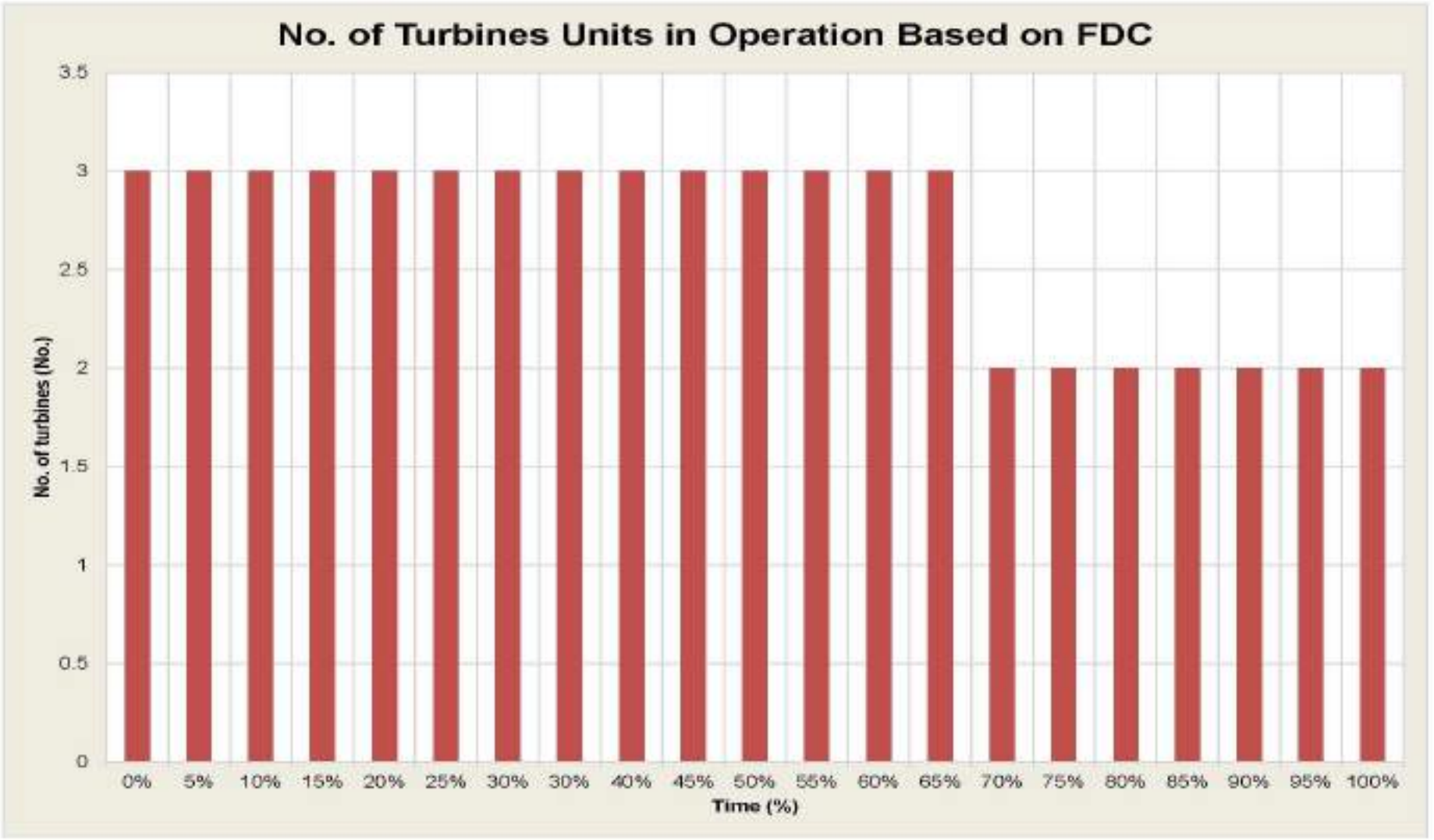
TIME INCR.		PERIOD	FLOW DURATION	NET HEAD	TURBINE - 1				TURBINE - 2				TURBINE - 3				Total Power	ANNUAL ENERGY
					Q_1	η_1	P_{out1}	$E_{annual1}$	Q_2	η_2	P_{out2}	$E_{annual2}$	Q_3	η_3	P_{out3}	$E_{annual3}$	$P=P1+P2+P3+P4$	Total
Hours	(%)	(Years)	(m^3/s)	(m)	(m^3/s)	(%)	(MW)	(GWh)	(m^3/s)	(%)	(MW)	(GWh)	(m^3/s)	(%)	(MW)	(GWh)	(MW)	(GWh)
185	50.7%	5	60.136	106.0	20.000	93.3%	18.369	2.204	20.000	93.3%	18.369	2.204	20.000	93.3%	18.369	2.204	55.108	6.613
190	52.1%	5	57.807	106.0	19.269	93.5%	17.728	2.127	19.269	93.5%	17.728	2.127	19.269	93.5%	17.728	2.127	53.186	6.382
195	53.4%	5	55.478	106.0	18.493	93.6%	17.045	2.045	18.493	93.6%	17.045	2.045	18.493	93.6%	17.045	2.045	51.135	6.136
200	54.8%	5	53.148	106.0	17.716	93.5%	16.309	1.957	17.716	93.5%	16.309	1.957	17.716	93.5%	16.309	1.957	48.926	5.871
205	56.2%	5	50.821	106.0	16.940	93.2%	15.541	1.865	16.940	93.2%	15.541	1.865	16.940	93.2%	15.541	1.865	46.623	5.595
210	57.5%	5	48.492	106.0	16.164	92.9%	14.778	1.773	16.164	92.9%	14.778	1.773	16.164	92.9%	14.778	1.773	44.336	5.320
215	58.9%	5	46.163	106.0	15.388	92.6%	14.021	1.682	15.388	92.6%	14.021	1.682	15.388	92.6%	14.021	1.682	42.062	5.047
220	60.3%	5	44.073	106.0	14.691	91.8%	13.274	1.593	14.691	91.8%	13.274	1.593	14.691	91.8%	13.274	1.593	39.823	4.779
225	61.6%	5	42.936	106.0	14.312	91.0%	12.826	1.539	14.312	91.0%	12.826	1.539	14.312	91.0%	12.826	1.539	38.478	4.617
230	63.0%	5	41.799	106.0	13.933	90.3%	12.384	1.486	13.933	90.3%	12.384	1.486	13.933	90.3%	12.384	1.486	37.151	4.458
235	64.4%	5	40.662	106.0	13.554	89.5%	11.947	1.434	13.554	89.5%	11.947	1.434	13.554	89.5%	11.947	1.434	35.840	4.301
240	65.8%	5	39.525	106.0	19.762	93.4%	18.161	2.179	19.762	93.4%	18.161	2.179	0.000	0.0%	0.000	0.000	36.322	4.359
245	67.1%	5	38.388	106.0	19.194	93.5%	17.682	2.119	19.194	93.5%	17.682	2.119	0.000	0.0%	0.000	0.000	35.324	4.239
250	68.5%	5	37.251	106.0	18.625	93.6%	17.162	2.059	18.625	93.6%	17.162	2.059	0.000	0.0%	0.000	0.000	34.324	4.119
255	69.9%	5	36.114	106.0	18.057	93.6%	16.647	1.998	18.057	93.6%	16.647	1.998	0.000	0.0%	0.000	0.000	33.293	3.995
260	71.2%	5	35.297	106.0	17.649	93.5%	16.241	1.949	17.649	93.5%	16.241	1.949	0.000	0.0%	0.000	0.000	32.483	3.898
265	72.6%	5	34.519	106.0	17.258	93.3%	15.855	1.903	17.258	93.3%	15.855	1.903	0.000	0.0%	0.000	0.000	31.710	3.805
270	74.0%	5	33.736	106.0	16.868	93.2%	15.470	1.856	16.868	93.2%	15.470	1.856	0.000	0.0%	0.000	0.000	30.938	3.713
275	75.3%	5	32.955	106.0	16.477	93.0%	15.086	1.810	16.477	93.0%	15.086	1.810	0.000	0.0%	0.000	0.000	30.172	3.621
280	76.7%	5	32.174	106.0	16.087	92.8%	14.703	1.764	16.087	92.8%	14.703	1.764	0.000	0.0%	0.000	0.000	29.406	3.529
285	78.1%	5	31.393	106.0	15.697	92.7%	14.322	1.719	15.697	92.7%	14.322	1.719	0.000	0.0%	0.000	0.000	28.643	3.437
290	79.5%	5	30.612	106.0	15.306	92.5%	13.941	1.673	15.306	92.5%	13.941	1.673	0.000	0.0%	0.000	0.000	27.883	3.346
295	80.8%	5	29.963	106.0	14.982	92.4%	13.622	1.635	14.982	92.4%	13.622	1.635	0.000	0.0%	0.000	0.000	27.244	3.269
300	82.2%	5	29.401	106.0	14.701	91.8%	13.286	1.594	14.701	91.8%	13.286	1.594	0.000	0.0%	0.000	0.000	26.572	3.189
305	83.6%	5	28.840	106.0	14.420	91.3%	12.953	1.554	14.420	91.3%	12.953	1.554	0.000	0.0%	0.000	0.000	25.906	3.109
310	84.9%	5	28.278	106.0	14.139	90.7%	12.624	1.515	14.139	90.7%	12.624	1.515	0.000	0.0%	0.000	0.000	25.247	3.030
315	86.3%	5	27.716	106.0	13.858	90.1%	12.297	1.476	13.858	90.1%	12.297	1.476	0.000	0.0%	0.000	0.000	24.594	2.951

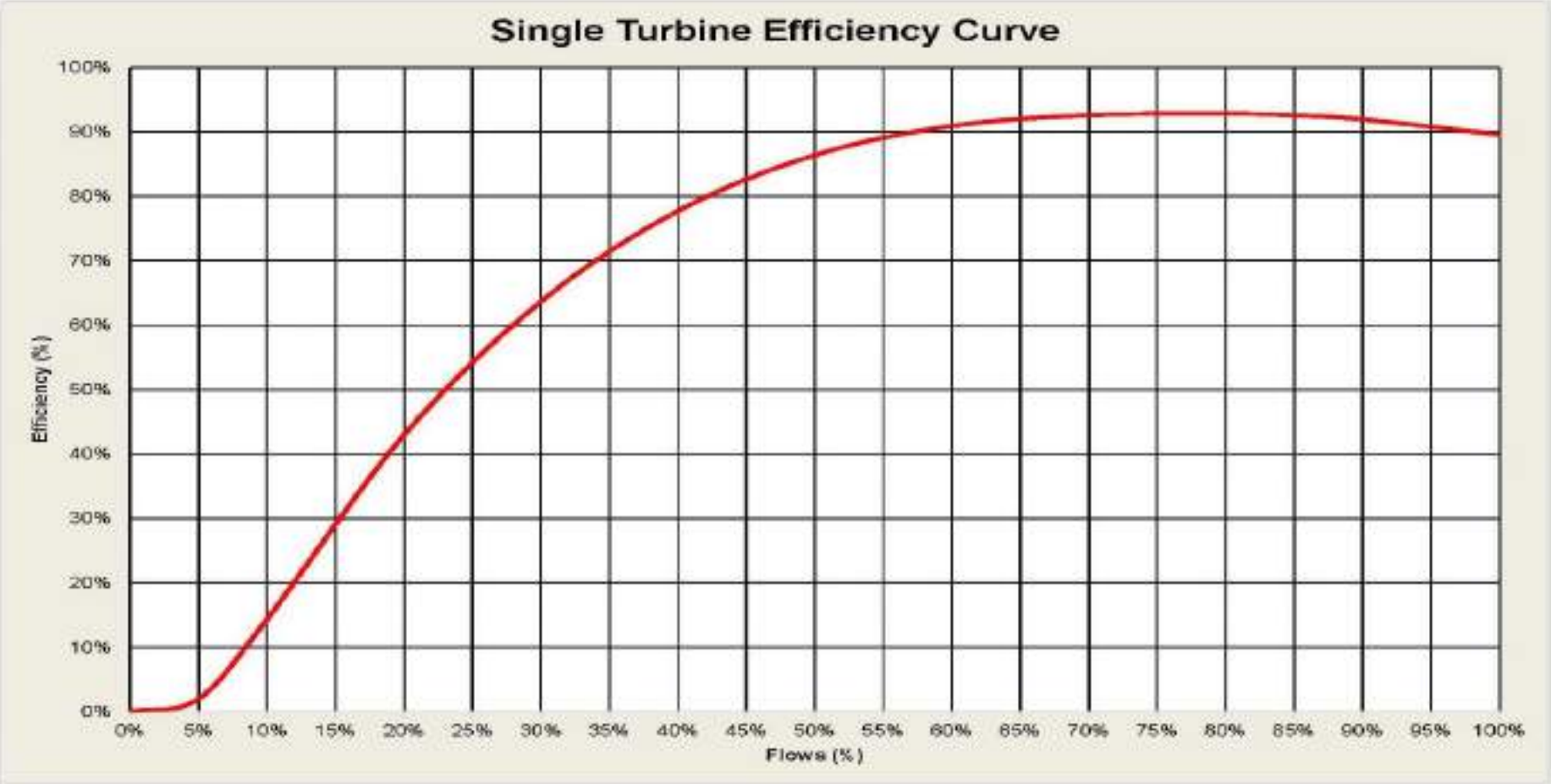
TIME INCR.		PERIOD	FLOW DURATION	NET HEAD	TURBINE - 1				TURBINE - 2				TURBINE - 3				Total Power	ANNUAL ENERGY
					Q_1	η_{T1}	$Power_1$	$Energy_1$	Q_2	η_{T2}	$Power_2$	$Energy_2$	Q_3	η_{T3}	$Power_3$	$Energy_3$	P=P1+P2 +P3+P4	Total
(days)	(%)	(days)	(m^3/s)	(m)	(m^3/s)	(%)	(MW)	(GWh)	(m^3/s)	(%)	(MW)	(GWh)	(m^3/s)	(%)	(MW)	(GWh)	(MW)	(GWh)
320	87.7%	5	27.155	106.0	13.577	89.6%	11.974	1.437	13.577	89.6%	11.974	1.437	0.000	0.0%	0.000	0.000	23.947	2.874
325	89.0%	5	26.593	106.0	13.297	89.0%	11.653	1.398	13.297	89.0%	11.653	1.398	0.000	0.0%	0.000	0.000	23.306	2.797
330	90.4%	5	25.966	106.0	12.983	88.4%	11.299	1.356	12.983	88.4%	11.299	1.356	0.000	0.0%	0.000	0.000	22.598	2.712
335	91.8%	5	25.185	106.0	12.592	87.6%	10.863	1.304	12.592	87.6%	10.863	1.304	0.000	0.0%	0.000	0.000	21.726	2.607
340	93.2%	5	24.404	106.0	12.202	86.9%	10.434	1.252	12.202	86.9%	10.434	1.252	0.000	0.0%	0.000	0.000	20.867	2.504
345	94.5%	5	23.623	106.0	11.812	86.1%	10.010	1.201	11.812	86.1%	10.010	1.201	0.000	0.0%	0.000	0.000	20.020	2.402
350	95.9%	5	22.842	106.0	11.421	85.3%	9.592	1.151	11.421	85.3%	9.592	1.151	0.000	0.0%	0.000	0.000	19.184	2.302
355	97.3%	5	22.062	106.0	11.031	84.5%	9.180	1.102	11.031	84.5%	9.180	1.102	0.000	0.0%	0.000	0.000	18.360	2.203
360	98.6%	5	21.281	106.0	10.640	83.8%	8.774	1.053	10.640	83.8%	8.774	1.053	0.000	0.0%	0.000	0.000	17.549	2.106
365	100.0%	5	20.500	106.0	10.250	83.0%	8.374	1.005	10.250	83.0%	8.374	1.005	0.000	0.0%	0.000	0.000	16.748	2.010
MEAN ANNUAL ENERGY (GWh)								=										**384.60**
Annual Downtime Losses 10 days closure)								=										2.74%
Actual Mean Annual Energy (GWh)								=										**374.1**

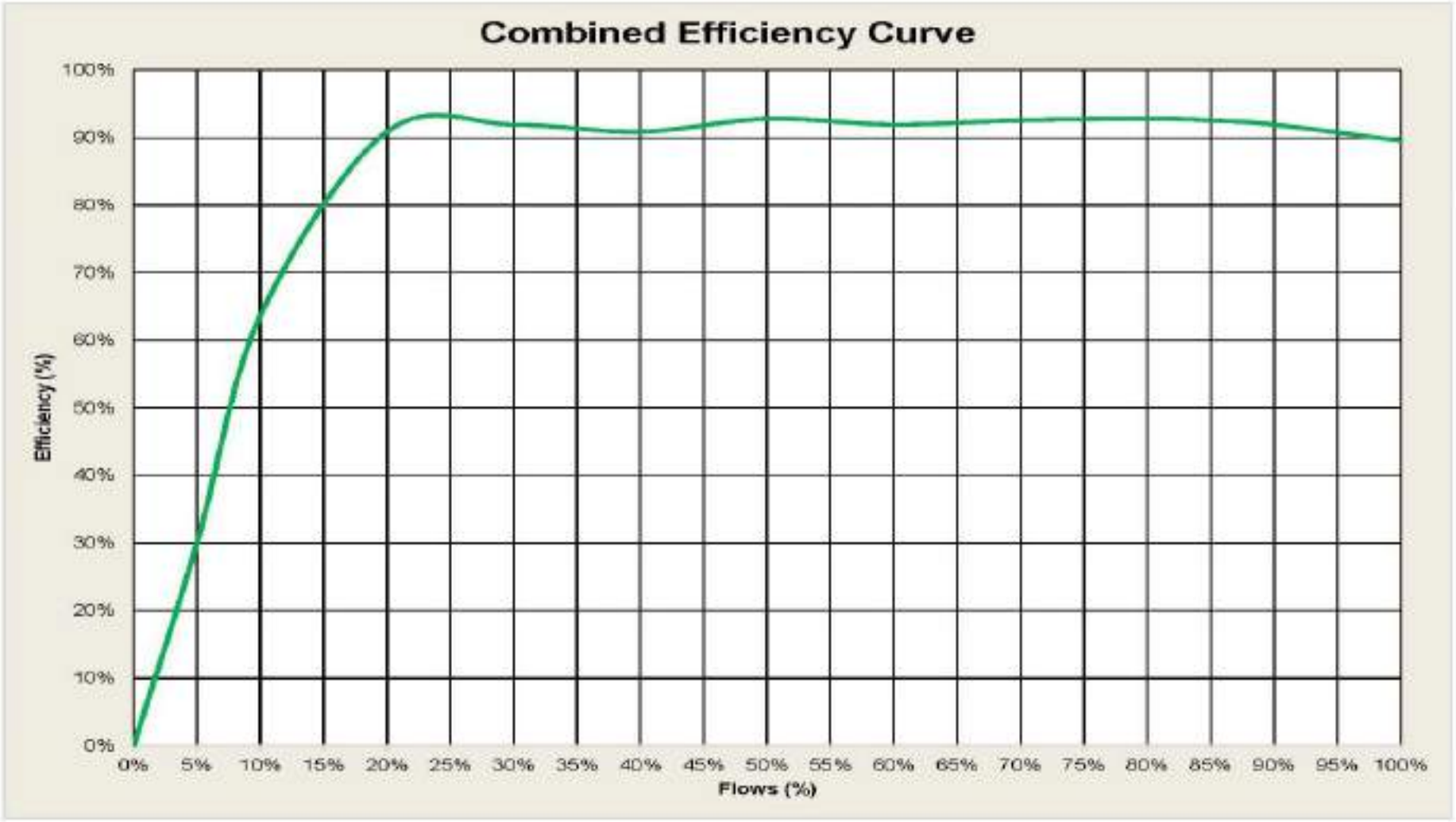
$$\text{Plant Factor} = \frac{374.1 \times 10^6}{54.04 \times 8760000} = \frac{\text{Actual Energy}}{\text{Theoretical Energy}}$$

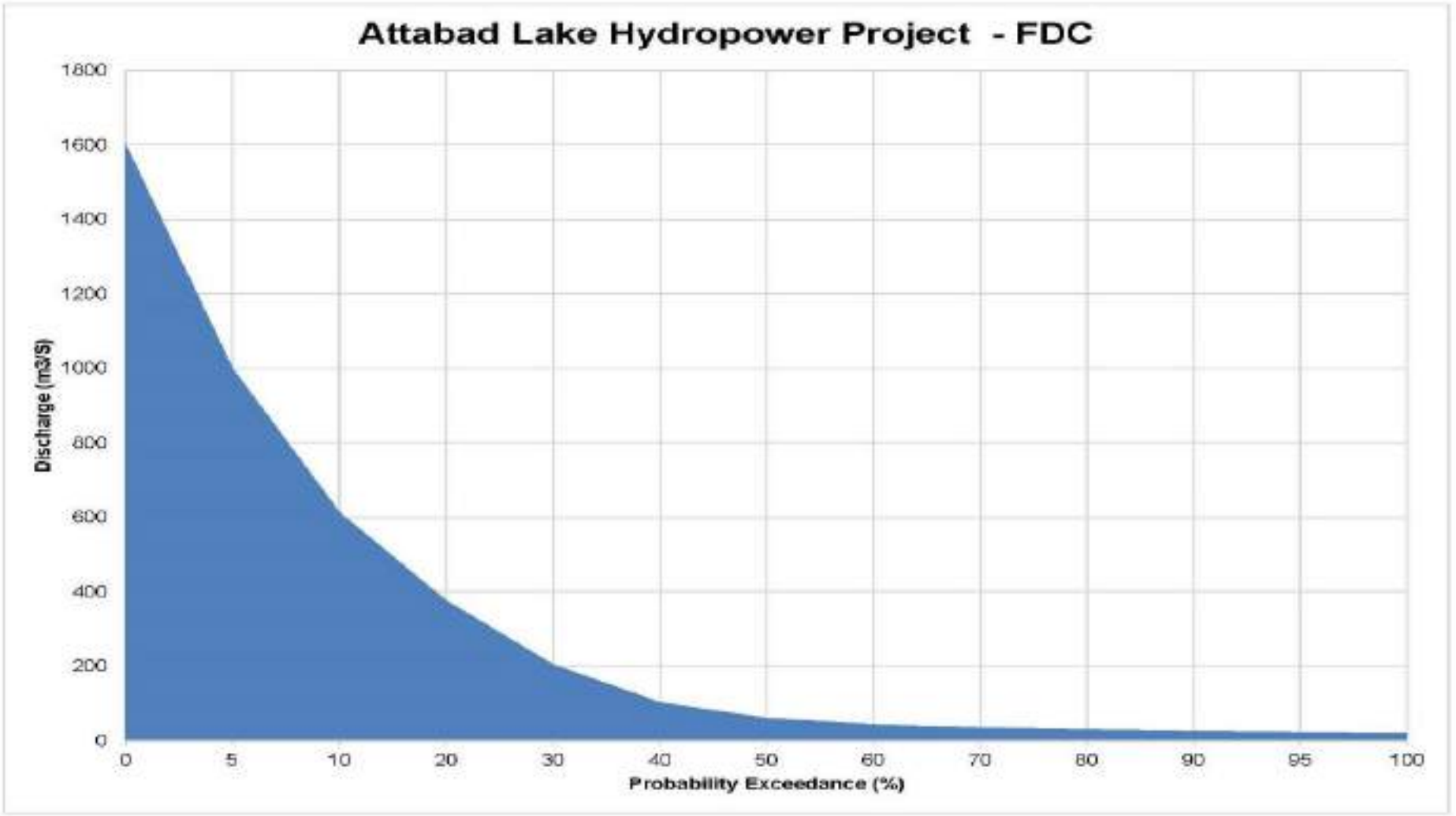
Plant Factor = **79.01%**

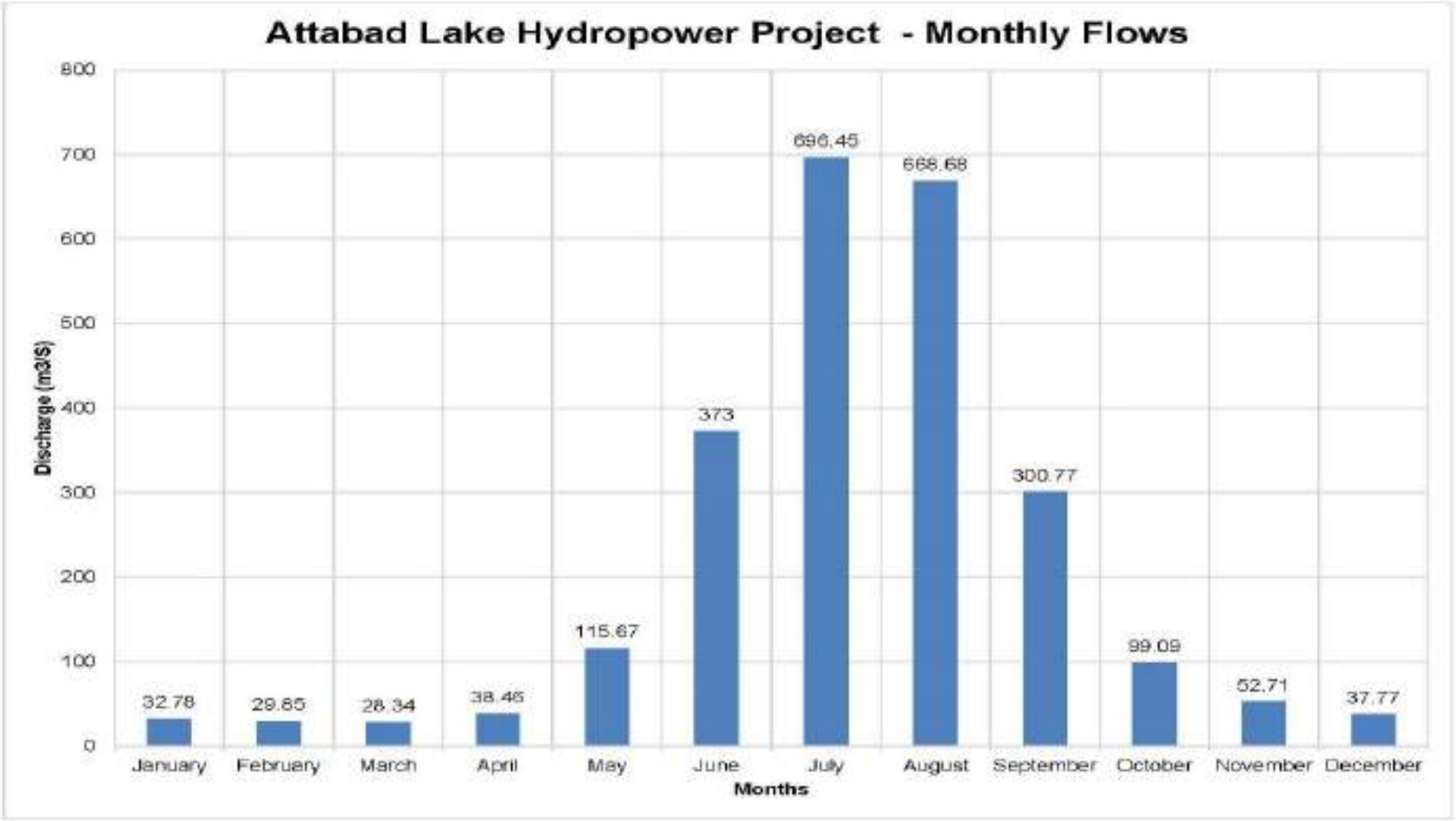

Attabad Lake Hydropower Project - Power Curve
Power
Energy
Power (MW)
Cumulative Energy (GWh)
Time (%)
0
5
10
15
20
25
30
35
40
45
50
55
60
0
25
50
75
100
125
150
175
200
225
250
275
300
325
350
375
400
0.0%
10.0%
20.0%
30.0%
40.0%
50.0%
60.0%
70.0%
80.0%
90.0%
100.0%


No. of Turbines Units in Operation Based on FDC
No. of turbines (No.)
3.5
3
2.5
2
1.5
1
0.5
0
0%
5%
10%
15%
20%
25%
30%
30%
40%
45%
50%
55%
60%
65%
70%
75%
80%
85%
90%
95%
100%
Time (%)


Single Turbine Efficiency Curve
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
Efficiency (%)
0%
5%
10%
15%
20%
25%
30%
35%
40%
45%
50%
55%
60%
65%
70%
75%
80%
85%
90%
95%
100%
Flows (%)


Combined Efficiency Curve
Efficiency (%)
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
0% 5% 10% 15% 20% 25% 30% 35% 40% 45% 50% 55% 60% 65% 70% 75% 80% 85% 90% 95% 100%
Flows (%)


Attabad Lake Hydropower Project - FDC
Discharge (m3/S)
1800
1600
1400
1200
1000
800
600
400
200
0
0
5
10
20
30
40
50
60
70
80
90
95
100
Probability Exceedance (%)


Attabad Lake Hydropower Project - Monthly Flows
Discharge (m3/S)
800
700
600
500
400
300
200
100
0
32.78
29.65
28.34
38.46
115.67
373
696.45
668.68
300.77
99.09
52.71
37.77
January
February
March
April
May
June
July
August
September
October
November
December
Months

8.4.3 Power and Energy Calculations based on Flow Duration Curve (FDC) method with Four (04) No. of Generating Units

ATTABAD LAKE HYDROPOWER PROJECT

TABLE 8.3

POWER AND ENERGY CALCULATIONS

(FLOW DURATION CURVE METHOD)

Design Discharge	Q_D	=	60.0	m^3/sec
Environmental Flows	Q_E	=	0.00	m^3/sec
No. of Units		=	4	FRANCIS
Design Discharge (single unit)	$Q_{D/S}$	=	15.000	m^3/sec
Gross Head	H_g	=	112.00	m
Head Loss	H_L	=	6.00	m
Net Head	H_n	=	106.00	m
Turbine Efficiency at Design Discharge	η_T	=	91.5%	
Generator Efficiency	η_G	=	96.8%	
Transformer Efficiency	η_{Tr}	=	98.0%	
Flushing Period	T_{FL}	=	10	days

GROSS POWER	64.94	MW
ANNUAL ENERGY	370.14	GWh
PLANT FACTOR	78.451	%

TIME		PERIOD	FLOW DURATION	NET HEAD	TURBINE - 1				TURBINE - 2				TURBINE - 3				TURBINE - 4				TOTAL POWER	ANNUAL ENERGY
					Q_1	η_1	Power	Energy	Q_2	η_2	Power	Energy	Q_3	η_3	Power	Energy	Q_4	η_4	Power	Energy	$P=P1+P2+P3+P4$	Total
days	%	days	m^3/s	m	m^3/s	%	MW	GWh	m^3/s	%	MW	GWh	m^3/s	%	MW	GWh	m^3/s	%	MW	GWh	MW	GWh
1	0.3%	4	1567.123	106.0	15.000	92.3%	13.777	1.223	15.000	92.3%	13.777	1.223	15.000	92.3%	13.777	1.223	15.000	92.3%	13.777	1.223	55.106	5.296
5	1.4%	5	1426.816	106.0	15.000	92.3%	13.777	1.653	15.000	92.3%	13.777	1.653	15.000	92.3%	13.777	1.653	15.000	92.3%	13.777	1.653	55.106	5.513
10	2.7%	5	1271.230	106.0	15.000	92.3%	13.777	1.653	15.000	92.3%	13.777	1.653	15.000	92.3%	13.777	1.653	15.000	92.3%	13.777	1.653	55.106	5.513
15	4.1%	5	1108.548	106.0	15.000	92.3%	13.777	1.653	15.000	92.3%	13.777	1.653	15.000	92.3%	13.777	1.653	15.000	92.3%	13.777	1.653	55.106	5.513
20	5.5%	5	982.929	106.0	15.000	92.3%	13.777	1.653	15.000	92.3%	13.777	1.653	15.000	92.3%	13.777	1.653	15.000	92.3%	13.777	1.653	55.106	5.513
25	6.8%	5	857.011	106.0	15.000	92.3%	13.777	1.653	15.000	92.3%	13.777	1.653	15.000	92.3%	13.777	1.653	15.000	92.3%	13.777	1.653	55.106	5.513
30	8.2%	5	751.093	106.0	15.000	92.3%	13.777	1.653	15.000	92.3%	13.777	1.653	15.000	92.3%	13.777	1.653	15.000	92.3%	13.777	1.653	55.106	5.513
35	9.6%	5	645.175	106.0	15.000	92.3%	13.777	1.653	15.000	92.3%	13.777	1.653	15.000	92.3%	13.777	1.653	15.000	92.3%	13.777	1.653	55.106	5.513
40	11.0%	5	590.083	106.0	15.000	92.3%	13.777	1.653	15.000	92.3%	13.777	1.653	15.000	92.3%	13.777	1.653	15.000	92.3%	13.777	1.653	55.106	5.513
45	12.3%	5	555.258	106.0	15.000	92.3%	13.777	1.653	15.000	92.3%	13.777	1.653	15.000	92.3%	13.777	1.653	15.000	92.3%	13.777	1.653	55.106	5.513
50	13.7%	5	520.519	106.0	15.000	92.3%	13.777	1.653	15.000	92.3%	13.777	1.653	15.000	92.3%	13.777	1.653	15.000	92.3%	13.777	1.653	55.106	5.513
55	15.1%	5	493.378	106.0	15.000	92.3%	13.777	1.653	15.000	92.3%	13.777	1.653	15.000	92.3%	13.777	1.653	15.000	92.3%	13.777	1.653	55.106	5.513
60	16.4%	5	460.048	106.0	15.000	92.3%	13.777	1.653	15.000	92.3%	13.777	1.653	15.000	92.3%	13.777	1.653	15.000	92.3%	13.777	1.653	55.106	5.513
65	17.8%	5	426.561	106.0	15.000	92.3%	13.777	1.653	15.000	92.3%	13.777	1.653	15.000	92.3%	13.777	1.653	15.000	92.3%	13.777	1.653	55.106	5.513
70	19.2%	5	396.063	106.0	15.000	92.3%	13.777	1.653	15.000	92.3%	13.777	1.653	15.000	92.3%	13.777	1.653	15.000	92.3%	13.777	1.653	55.106	5.513
75	20.5%	5	367.197	106.0	15.000	92.3%	13.777	1.653	15.000	92.3%	13.777	1.653	15.000	92.3%	13.777	1.653	15.000	92.3%	13.777	1.653	55.106	5.513
80	21.8%	5	343.089	106.0	15.000	92.3%	13.777	1.653	15.000	92.3%	13.777	1.653	15.000	92.3%	13.777	1.653	15.000	92.3%	13.777	1.653	55.106	5.513

TIME INCR.		PERIOD	FLOW DURATION	NET HEAD	TURBINE - 1				TURBINE - 2				TURBINE - 3				TURBINE - 4				Total Power (P1+P2+P3+P4)	ANNUAL ENERGY
					Q_1	η_1	$Power_1$	$Energy_1$	Q_2	η_2	$Power_2$	$Energy_2$	Q_3	η_3	$Power_3$	$Energy_3$	Q_4	η_4	$Power_4$	$Energy_4$		Total
(Hours)	(%)	(Hours)	(m^3/s)	(m)	(m^3/s)	(%)	(MW)	(GWh)	(m^3/s)	(%)	(MW)	(GWh)	(m^3/s)	(%)	(MW)	(GWh)	(m^3/s)	(%)	(MW)	(GWh)	(MW)	(GWh)
85	23.3%	5	320.184	106.0	15.000	93.3%	13.777	1.653	15.000	93.3%	13.777	1.653	15.000	93.3%	13.777	1.653	15.000	93.3%	13.777	1.653	55.106	6.613
90	24.7%	5	296.627	106.0	15.000	93.3%	13.777	1.653	15.000	93.3%	13.777	1.653	15.000	93.3%	13.777	1.653	15.000	93.3%	13.777	1.653	55.106	6.613
95	26.0%	6	273.170	106.0	15.000	93.3%	13.777	1.653	15.000	93.3%	13.777	1.653	15.000	93.3%	13.777	1.653	15.000	93.3%	13.777	1.653	55.106	6.613
100	27.4%	5	249.663	106.0	15.000	93.3%	13.777	1.653	15.000	93.3%	13.777	1.653	15.000	93.3%	13.777	1.653	15.000	93.3%	13.777	1.653	55.106	6.613
105	28.8%	5	226.156	106.0	15.000	93.3%	13.777	1.653	15.000	93.3%	13.777	1.653	15.000	93.3%	13.777	1.653	15.000	93.3%	13.777	1.653	55.106	6.613
110	30.1%	5	203.667	106.0	15.000	93.3%	13.777	1.653	15.000	93.3%	13.777	1.653	15.000	93.3%	13.777	1.653	15.000	93.3%	13.777	1.653	55.106	6.613
115	31.5%	6	188.676	106.0	15.000	93.3%	13.777	1.653	15.000	93.3%	13.777	1.653	15.000	93.3%	13.777	1.653	15.000	93.3%	13.777	1.653	55.106	6.613
120	32.9%	5	175.744	106.0	15.000	93.3%	13.777	1.653	15.000	93.3%	13.777	1.653	15.000	93.3%	13.777	1.653	15.000	93.3%	13.777	1.653	55.106	6.613
125	34.2%	6	161.612	106.0	15.000	93.3%	13.777	1.653	15.000	93.3%	13.777	1.653	15.000	93.3%	13.777	1.653	15.000	93.3%	13.777	1.653	55.106	6.613
130	35.6%	5	147.081	106.0	15.000	93.3%	13.777	1.653	15.000	93.3%	13.777	1.653	15.000	93.3%	13.777	1.653	15.000	93.3%	13.777	1.653	55.106	6.613
135	37.0%	5	133.949	106.0	15.000	93.3%	13.777	1.653	15.000	93.3%	13.777	1.653	15.000	93.3%	13.777	1.653	15.000	93.3%	13.777	1.653	55.106	6.613
140	38.4%	5	120.018	106.0	15.000	93.3%	13.777	1.653	15.000	93.3%	13.777	1.653	15.000	93.3%	13.777	1.653	15.000	93.3%	13.777	1.653	55.106	6.613
145	39.7%	5	106.086	106.0	15.000	93.3%	13.777	1.653	15.000	93.3%	13.777	1.653	15.000	93.3%	13.777	1.653	15.000	93.3%	13.777	1.653	55.106	6.613
150	41.1%	5	93.897	106.0	15.000	93.3%	13.777	1.653	15.000	93.3%	13.777	1.653	15.000	93.3%	13.777	1.653	15.000	93.3%	13.777	1.653	55.106	6.613
155	42.5%	5	82.844	106.0	15.000	93.3%	13.777	1.653	15.000	93.3%	13.777	1.653	15.000	93.3%	13.777	1.653	15.000	93.3%	13.777	1.653	55.106	6.613
160	43.9%	5	67.193	106.0	15.000	93.3%	13.777	1.653	15.000	93.3%	13.777	1.653	15.000	93.3%	13.777	1.653	15.000	93.3%	13.777	1.653	55.106	6.613
165	45.2%	5	61.437	106.0	15.000	93.3%	13.777	1.653	15.000	93.3%	13.777	1.653	15.000	93.3%	13.777	1.653	15.000	93.3%	13.777	1.653	55.106	6.613
170	46.6%	5	75.894	106.0	15.000	93.3%	13.777	1.653	15.000	93.3%	13.777	1.653	15.000	93.3%	13.777	1.653	15.000	93.3%	13.777	1.653	55.106	6.613
175	47.9%	5	69.939	106.0	15.000	93.3%	13.777	1.653	15.000	93.3%	13.777	1.653	15.000	93.3%	13.777	1.653	15.000	93.3%	13.777	1.653	55.106	6.613
180	49.3%	5	64.177	106.0	15.000	93.3%	13.777	1.653	15.000	93.3%	13.777	1.653	15.000	93.3%	13.777	1.653	15.000	93.3%	13.777	1.653	55.106	6.613
185	50.7%	5	60.139	106.0	15.000	93.3%	13.777	1.653	15.000	93.3%	13.777	1.653	15.000	93.3%	13.777	1.653	15.000	93.3%	13.777	1.653	55.106	6.613
190	52.1%	6	57.897	106.0	14.462	93.5%	13.296	1.596	14.462	93.5%	13.296	1.596	14.462	93.5%	13.296	1.596	14.462	93.5%	13.296	1.596	53.185	6.382
195	53.4%	5	55.479	106.0	13.870	93.6%	12.764	1.534	13.870	93.6%	12.764	1.534	13.870	93.6%	12.764	1.534	13.870	93.6%	12.764	1.534	51.130	6.139
200	54.8%	5	53.149	106.0	13.287	93.6%	12.231	1.468	13.287	93.6%	12.231	1.468	13.287	93.6%	12.231	1.468	13.287	93.6%	12.231	1.468	48.926	5.871
205	56.2%	5	50.821	106.0	12.705	93.2%	11.656	1.399	12.705	93.2%	11.656	1.399	12.705	93.2%	11.656	1.399	12.705	93.2%	11.656	1.399	46.823	5.595
210	57.5%	6	48.492	106.0	12.123	92.9%	11.064	1.330	12.123	92.9%	11.064	1.330	12.123	92.9%	11.064	1.330	12.123	92.9%	11.064	1.330	44.256	5.320
215	58.9%	5	46.163	106.0	11.541	92.6%	10.515	1.262	11.541	92.6%	10.515	1.262	11.541	92.6%	10.515	1.262	11.541	92.6%	10.515	1.262	42.062	5.047
220	60.3%	5	44.073	106.0	14.691	93.4%	13.509	1.621	14.691	93.4%	13.509	1.621	14.691	93.4%	13.509	1.621	0.000	0.0%	0.000	0.000	40.519	4.862
225	61.6%	5	42.038	106.0	14.212	93.5%	13.173	1.581	14.212	93.5%	13.173	1.581	14.212	93.5%	13.173	1.581	0.000	0.0%	0.000	0.000	39.520	4.742
230	63.0%	5	41.799	106.0	13.933	93.6%	12.948	1.641	13.933	93.6%	12.948	1.641	13.933	93.6%	12.948	1.641	0.000	0.0%	0.000	0.000	38.519	4.622
235	64.4%	5	40.882	106.0	13.664	93.7%	12.496	1.600	13.664	93.7%	12.496	1.600	13.664	93.7%	12.496	1.600	0.000	0.0%	0.000	0.000	37.456	4.499
240	65.8%	5	39.828	106.0	13.178	93.4%	12.129	1.454	13.178	93.4%	12.129	1.454	13.178	93.4%	12.129	1.454	0.000	0.0%	0.000	0.000	36.360	4.363
245	67.1%	6	38.388	106.0	12.796	93.2%	11.748	1.409	12.796	93.2%	11.748	1.409	12.796	93.2%	11.748	1.409	0.000	0.0%	0.000	0.000	35.236	4.228
250	68.5%	5	37.251	106.0	12.417	93.0%	11.372	1.365	12.417	93.0%	11.372	1.365	12.417	93.0%	11.372	1.365	0.000	0.0%	0.000	0.000	34.116	4.094

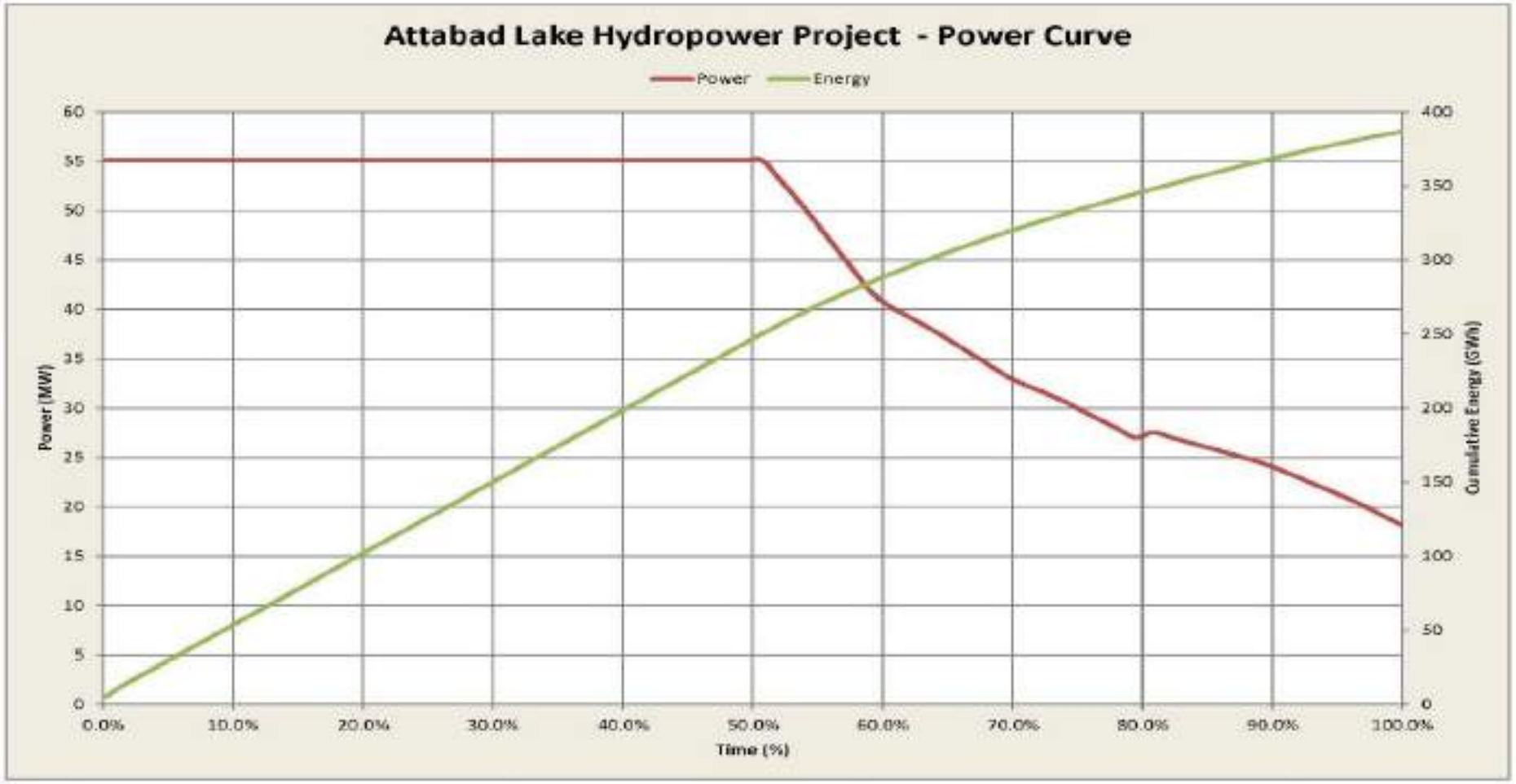
TIME IN DECIMAL		PERIOD	FLOW DURATION	NET HEAD	TURBINE - 1				TURBINE - 2				TURBINE - 3				TURBINE - 4				Total Power	ANNUAL ENERGY
					Q_1	η_1	Power$_1$	Energy$_1$	Q_2	η_2	Power$_2$	Energy$_2$	Q_3	η_3	Power$_3$	Energy$_3$	Q_4	η_4	Power$_4$	Energy$_4$	P=P1+P2 +P3+P4	Total
(days)	(%)	(days)	(m^3/s)	(m)	(m^3/s)	(%)	(MW)	(GWh)	(m^3/s)	(%)	(MW)	(GWh)	(m^3/s)	(%)	(MW)	(GWh)	(m^3/s)	(%)	(MW)	(GWh)	(MW)	(GWh)
255	69.9%	6	36.114	106.0	12.039	92.6%	11.001	1.320	12.039	92.6%	11.001	1.320	12.039	92.6%	11.001	1.320	0.000	0.0%	0.000	0.000	33.002	3.960
260	71.2%	6	36.297	106.0	11.766	92.7%	10.735	1.288	11.766	92.7%	10.735	1.288	11.766	92.7%	10.735	1.288	0.000	0.0%	0.000	0.000	32.204	3.864
265	72.6%	6	34.510	106.0	11.505	92.5%	10.491	1.259	11.505	92.5%	10.491	1.259	11.505	92.5%	10.491	1.259	0.000	0.0%	0.000	0.000	31.483	3.778
270	74.0%	6	33.726	106.0	11.245	92.4%	10.227	1.227	11.245	92.4%	10.227	1.227	11.245	92.4%	10.227	1.227	0.000	0.0%	0.000	0.000	30.682	3.682
275	75.3%	6	32.965	106.0	10.995	91.7%	9.816	1.178	10.995	91.7%	9.816	1.178	10.995	91.7%	9.816	1.178	0.000	0.0%	0.000	0.000	29.449	3.570
280	76.7%	6	32.174	106.0	10.725	91.0%	9.569	1.153	10.725	91.0%	9.569	1.153	10.725	91.0%	9.569	1.153	0.000	0.0%	0.000	0.000	28.625	3.459
285	78.1%	6	31.393	106.0	10.464	90.3%	9.305	1.117	10.464	90.3%	9.305	1.117	10.464	90.3%	9.305	1.117	0.000	0.0%	0.000	0.000	27.914	3.350
290	79.5%	6	30.612	106.0	10.204	89.6%	9.064	1.081	10.204	89.6%	9.064	1.081	10.204	89.6%	9.064	1.081	0.000	0.0%	0.000	0.000	27.013	3.242
295	80.8%	6	29.963	106.0	14.982	93.3%	13.761	1.651	14.982	93.3%	13.761	1.651	0.000	0.0%	0.000	0.000	0.000	0.0%	0.000	0.000	27.521	3.303
300	82.2%	6	29.401	106.0	14.701	93.4%	13.515	1.622	14.701	93.4%	13.515	1.622	0.000	0.0%	0.000	0.000	0.000	0.0%	0.000	0.000	27.029	3.244
305	83.6%	6	28.840	106.0	14.420	93.5%	13.258	1.592	14.420	93.5%	13.258	1.592	0.000	0.0%	0.000	0.000	0.000	0.0%	0.000	0.000	26.516	3.184
310	84.9%	6	28.278	106.0	14.139	93.6%	13.021	1.563	14.139	93.6%	13.021	1.563	0.000	0.0%	0.000	0.000	0.000	0.0%	0.000	0.000	26.042	3.125
315	86.3%	6	27.716	106.0	13.858	93.6%	12.774	1.533	13.858	93.6%	12.774	1.533	0.000	0.0%	0.000	0.000	0.000	0.0%	0.000	0.000	25.549	3.066
320	87.7%	6	27.155	106.0	13.577	93.7%	12.528	1.502	13.577	93.7%	12.528	1.502	0.000	0.0%	0.000	0.000	0.000	0.0%	0.000	0.000	25.056	3.005
325	89.0%	6	26.593	106.0	13.297	93.5%	12.241	1.469	13.297	93.5%	12.241	1.469	0.000	0.0%	0.000	0.000	0.000	0.0%	0.000	0.000	24.481	2.938
330	90.4%	6	25.969	106.0	12.993	93.3%	11.939	1.433	12.993	93.3%	11.939	1.433	0.000	0.0%	0.000	0.000	0.000	0.0%	0.000	0.000	23.993	2.879
335	91.8%	6	25.188	106.0	12.592	93.1%	11.546	1.385	12.592	93.1%	11.546	1.385	0.000	0.0%	0.000	0.000	0.000	0.0%	0.000	0.000	23.093	2.771
340	93.2%	6	24.404	106.0	12.202	92.9%	11.161	1.339	12.202	92.9%	11.161	1.339	0.000	0.0%	0.000	0.000	0.000	0.0%	0.000	0.000	22.323	2.679
345	94.5%	6	23.623	106.0	11.812	92.7%	10.779	1.294	11.812	92.7%	10.779	1.294	0.000	0.0%	0.000	0.000	0.000	0.0%	0.000	0.000	21.559	2.587
350	95.9%	6	22.842	106.0	11.421	92.5%	10.399	1.248	11.421	92.5%	10.399	1.248	0.000	0.0%	0.000	0.000	0.000	0.0%	0.000	0.000	20.798	2.496
355	97.3%	6	22.062	106.0	11.031	91.6%	9.971	1.196	11.031	91.6%	9.971	1.196	0.000	0.0%	0.000	0.000	0.000	0.0%	0.000	0.000	19.942	2.393
360	98.6%	6	21.281	106.0	10.640	90.6%	9.510	1.141	10.640	90.6%	9.510	1.141	0.000	0.0%	0.000	0.000	0.000	0.0%	0.000	0.000	19.020	2.282
365	100.0%	6	20.500	106.0	10.250	89.6%	9.057	1.087	10.250	89.6%	9.057	1.087	0.000	0.0%	0.000	0.000	0.000	0.0%	0.000	0.000	18.114	2.174
MEAN ANNUAL ENERGY (GWh)					=																	386.74

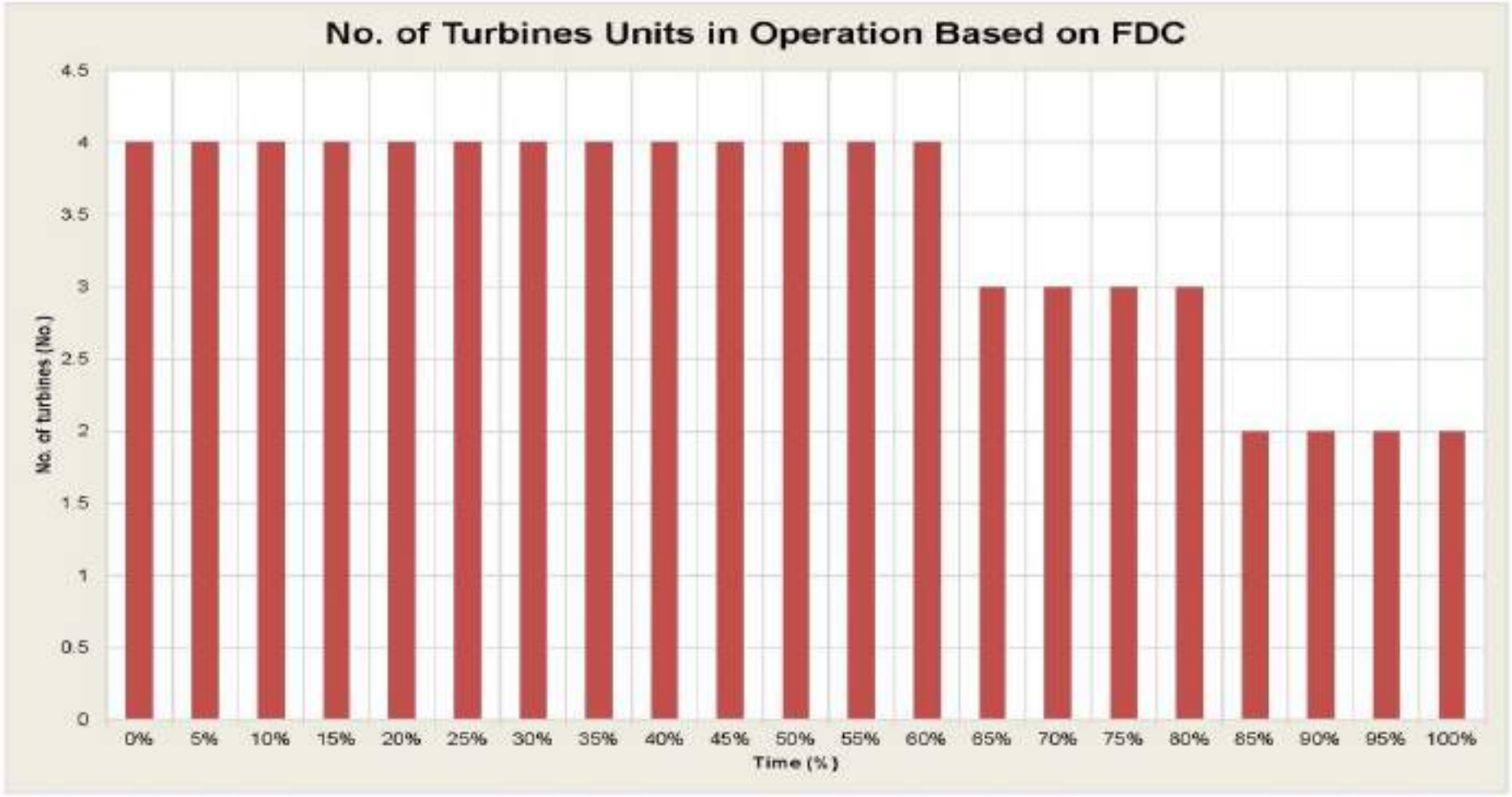
Annual Downtime Losse 10 days closure = 2.74%

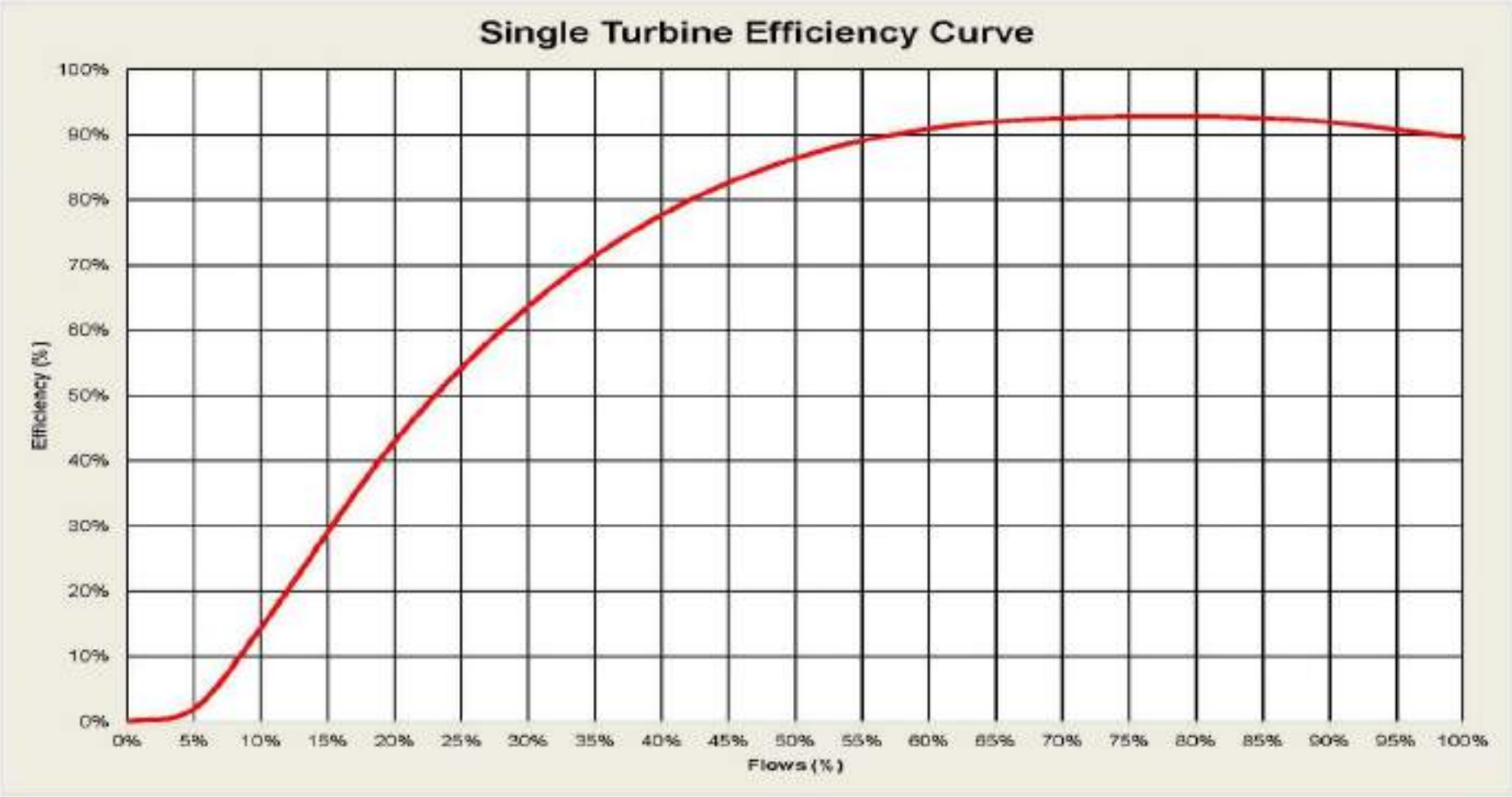
Actual Mean Annual Energy (GWh) = 376.1

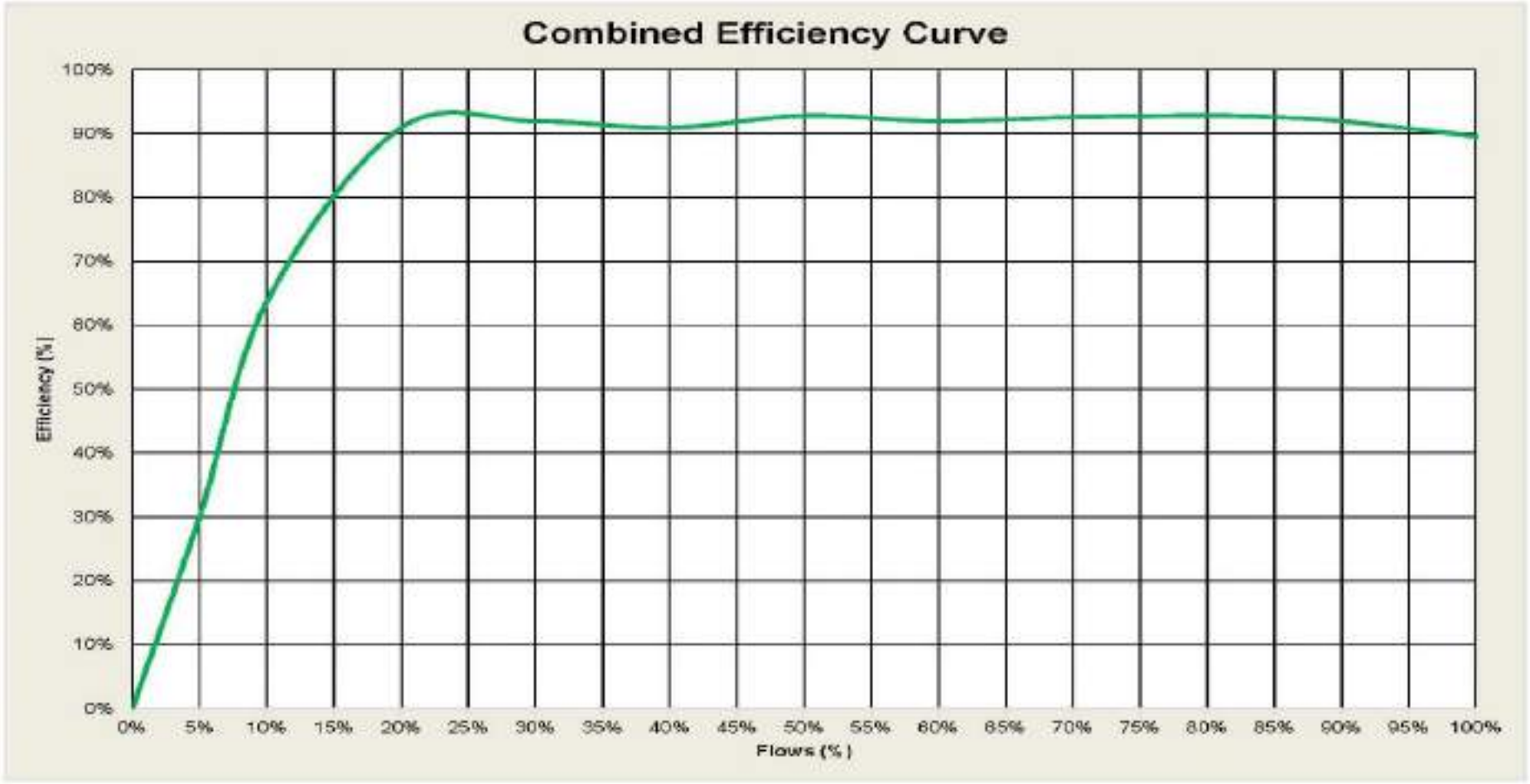
Plant Factor = $\frac{376.1 \times 10^6}{54.04 \times 8760.00}$ = $\frac{\text{Actual Energy}}{\text{Theortical Energy}}$

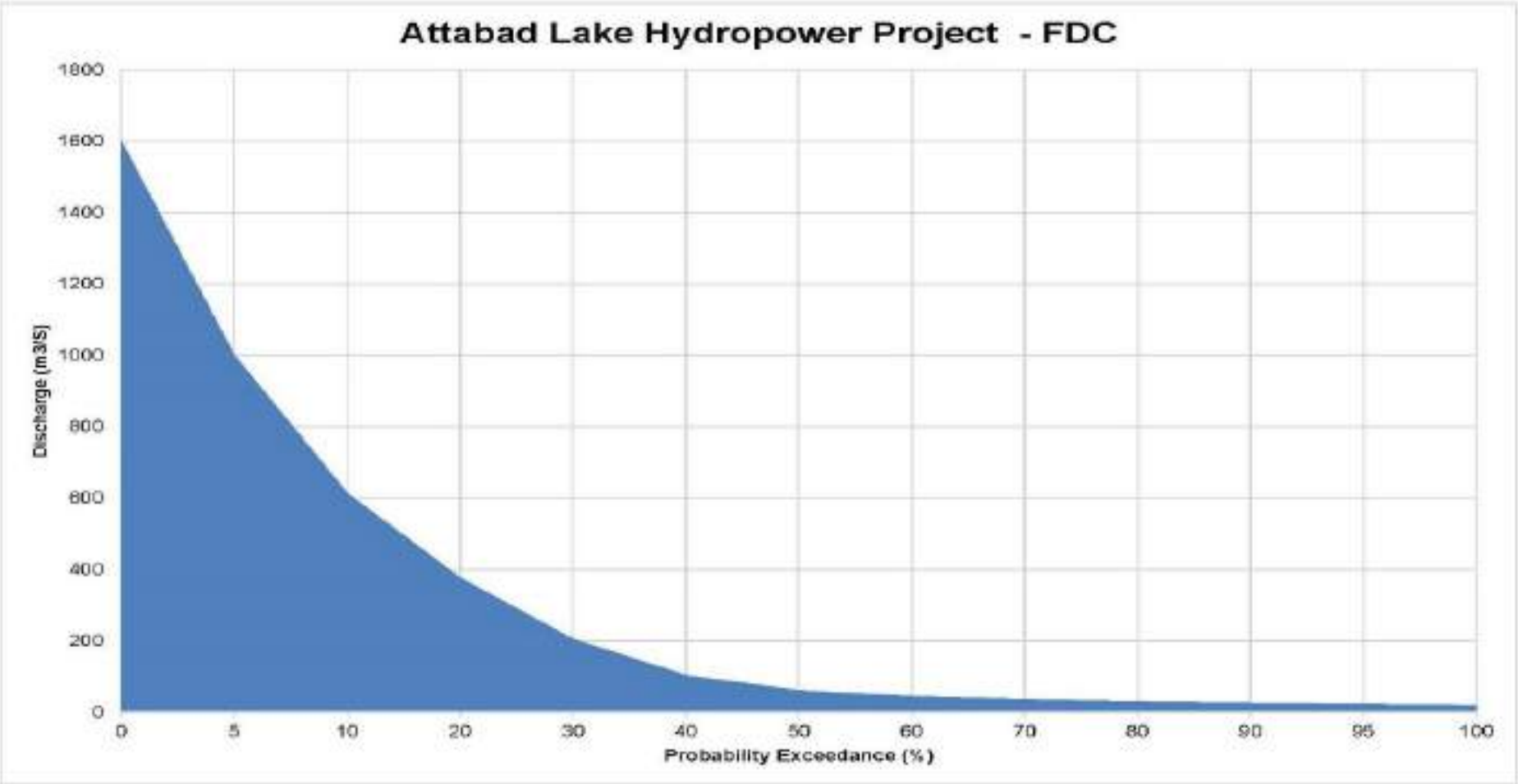
Plant Factor = **79.46%**

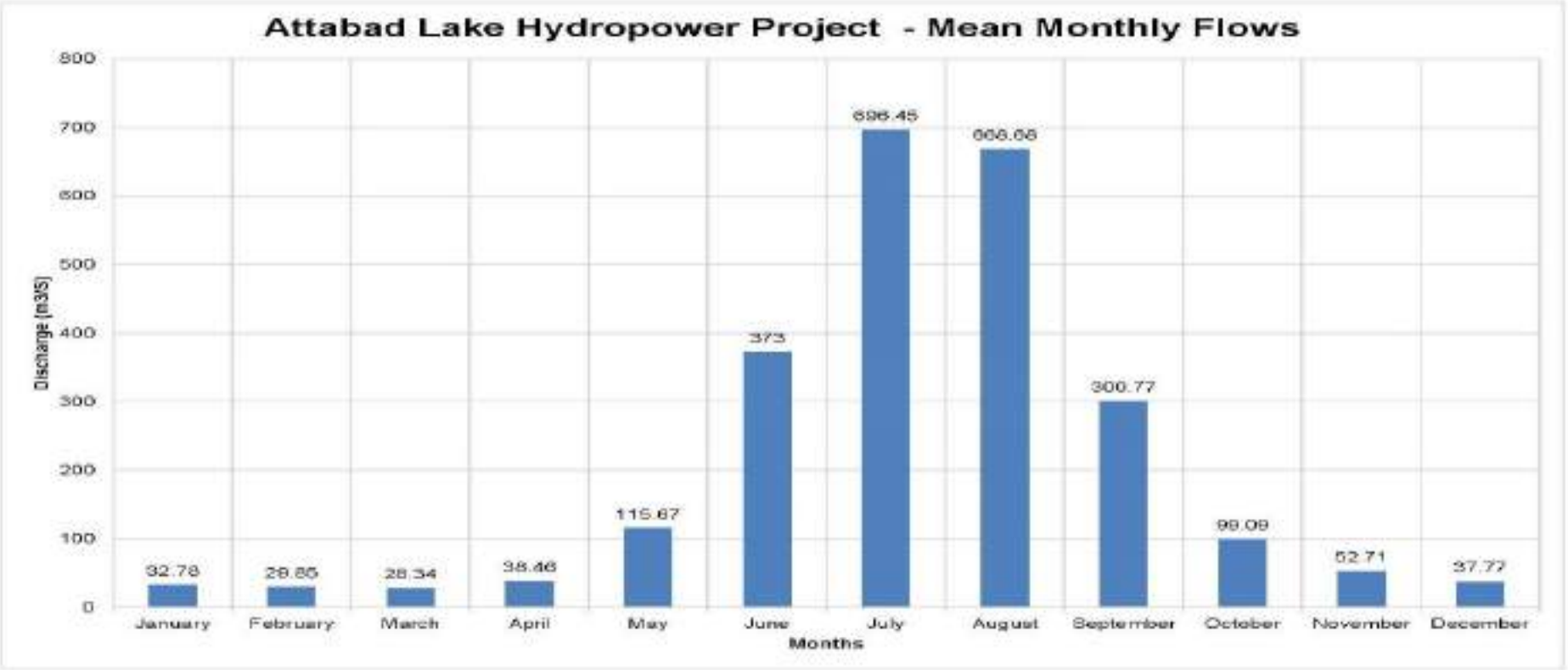

Attabad Lake Hydropower Project - Power Curve
Power
Energy
Power (MW)
Cumulative Energy (GWh)
Time (%)
0
5
10
15
20
25
30
35
40
45
50
55
60
0
50
100
150
200
250
300
350
400
0.0%
10.0%
20.0%
30.0%
40.0%
50.0%
60.0%
70.0%
80.0%
90.0%
100.0%


No. of Turbines Units in Operation Based on FDC
No. of turbines (No.)
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
0%
5%
10%
15%
20%
25%
30%
35%
40%
45%
50%
55%
60%
65%
70%
75%
80%
85%
90%
95%
100%
Time (%)


Single Turbine Efficiency Curve
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
Efficiency (%)
0%
5%
10%
15%
20%
25%
30%
35%
40%
45%
50%
55%
60%
65%
70%
75%
80%
85%
90%
95%
100%
Flows (%)


Combined Efficiency Curve
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
Efficiency (%)
0%
5%
10%
15%
20%
25%
30%
35%
40%
45%
50%
55%
60%
65%
70%
75%
80%
85%
90%
95%
100%
Flows (%)


Attabad Lake Hydropower Project - FDC
Discharge (m3/S)
1800
1600
1400
1200
1000
800
600
400
200
0
0
5
10
20
30
40
50
60
70
80
90
95
100
Probability Exceedance (%)


Attabad Lake Hydropower Project - Mean Monthly Flows
Discharge (m3/S)
800
700
600
500
400
300
200
100
0
32.78
28.85
28.34
38.46
115.67
373
696.45
666.68
300.77
98.09
52.71
37.77
January
February
March
April
May
June
July
August
September
October
November
December
Months

8.5 REVIEW FINDINGS

Based on verifying study and calculations MC are of the opinion that solution finalized in the Feasibility study with installed capacity of 54MW with 79% plant factor is most optimized solution.

However, as per recommendations from Mechanical expert, efficiency of turbine can be taken as 93%. MC endorse the selection of turbine with 93% efficiency which may result in little higher installed capacity of about 57 MW.

9 REVIEW OF STRUCTURE DESIGN STUDIES

9.1 GENERAL

In general, there are differences between values in the Feasibility Report and respective drawings. There are also differences for the same variable in the Feasibility Report in different sections. This issue should be corrected in the next design stages.

The inflow after the January 2010 land slide filled upstream valley created a 22 km long reservoir till the end of May 2010. The estimated lake initial storage was about 310 million m^3.

The deposited mass as a result of land slide is mainly composed of non-cohesive rock flour (fine dust, silt, silt gravels and cobbles) at the toe of the failed slope. Large boulders of granodioritic rocks with intrusions of granite, pegmatite and apatite were deposited close to the left bank of Hunza River. The deposit on the downstream side is composed of black clay with high plasticity and organic content. The upstream shoulder of the natural dam has mild slope and downstream slope is quite steep. With 2 km long dam, there is rare chance of piping failure. A view from Weir Site is shown in photograph given in Figure 9.1.

Figure 9.1: View from Attabad Lake HPP Reservoir

9.2 HYDRAULIC MODELLING OF RESERVOIR

The Hydrologic Engineering Center's River Analysis System (HEC-RAS 5.0.7) program has been used in the Feasibility Study of Attabad Lake HPP in order to analyze and assess the impact of design flood (3250 m^3/s) on the proposed system. A 1D-Unsteady numerical modeling has been used in the analysis. As a result of this analysis, it is found that there would be no major impact on the upstream settlements due to the overflow weir at 2414 m.a.s.l. and flood would remain within the river system. Weir site upstream and downstream views are given in photographs in Figure 9.2 and Figure 9.3.

In the feasibility dated 2021 prepared by WAPDA, hydrological data between 1966 to 2015 have been used. The latest information should be accessed and hydrology should be updated. It will be good for the health of the projects to observe the increases in the flood discharge due to global climate change in Pakistan in recent years and, if possible, to apply them to the projects.

The hydraulic model that has been prepared during the Feasibility Study is a suitable approach.

Figure 9.2: Weir Site Location Downstream View

Figure 9.3: Weir Site Location upstream view

9.3 NATURAL DAMMING ON HUNZA RIVER

It is possible that the lower elevations of the reservoir will be filled with sediment due to the construction of the body on the slide mass. The bottom spillway system in a classical dam is not within the scope of the project.

9.4 HYDRAULIC DESIGN

9.4.1 Hydraulic Design of Weir/Spillway and Stilling Basin

- **Weir/Spillway Discharge Capacity Overflow Ungated Structure**

In the feasibility report, it is mentioned that "The spillway discharge capacity at elevation 2421.4 masl is 3250 m³/s. along with overflow spillway, two low level flushing outlets would be in operation to discharge 600 m³/2. The total discharge through overflow weir/ungated spillway is 3250 m³/s, which is 10000 year return period. The spillway can therefore safely pass the PMF discharge with sufficient free board."

According to the drawings, the maximum flood water elevation is calculated as 2421.00 m and therefore the water head at the uncontrolled ogee shaped spillway is 7 m. However, the spillway discharge elevation is given as 2421.4 m in the section of the feasibility report 9.4.1.1, this incompatibility should be eliminated in the next design phase. It is not possible to pass Q_{10000}, that is, 3250 m³/sec, from the uncontrolled spillway with 60 m spillway width and 7 m water head.

Quick calculations show that the uncontrolled ogee shaped spillway has a discharge capacity of approximately 2400 m³/sec. The discharge capacity of the undersluice section, with a dimension of 5x5 m, having a hydraulic head of 16.5 m from the center of the opening is approximately 270 m³/sec. The total discharge capacity for 3 gates is approximately 810 m³/sec. The total discharge capaity of the uncontrolled and gated undersluice parts is 3210 m³/sec and it is very close to the design flood discharge. Therefore, the calculations can be considered accurate. Since the gated undersluice section of the spillway will work together with the uncontrolled ogee shaped spillway to evacuate the flood to the downstream, it is of great importance that the gates are always working. Therefore, reliable energy must be guaranteed for the weir location.

Weir sluice gate operation is vital for sediment flushing and full utilization of energy potential in accordance with the considerations expressed in the reservoir operating system given in Chapter 8.2 of Feasibility Report.

- **Design of Spillway Stilling Basin**

In this section of Feasibility Report, stilling basin design of the uncontrolled ogee shaped spillway has been done with the following dimensions:

Invert of stilling basin	2397.0 masl
Width of stilling basin	60.0 m
Elevation of river bed d/s	2400.00 masl
Length of stilling basin	55.0 m

There are inconsistencies between the elevations used in drawings and calculations. According to the control calculations, the calculations are generally confirmed, but the stilling basin wall top elevation in the drawings is insufficient compared to the calculations. In this framework, calculations and design compatibility should be ensured in the next stage.

9.4.2 Flushing Outlets

Three low level sediment flushing cum diversion outlets have been provided on the left bank upstream of the embankment dam to enable flushing of sediment in front of the power intakes in the Feasibility Study. Design of under sluice from Feasibility study is given below.

Maximum upstream Water Level	2421.4	m.a.s.l.
Maximum downstream Water Level	2405.0	m.a.s.l.
Upstream Bed Level	2400.0	m.a.s.l.
Downstream Bed Level	2400.0	m.a.s.l.
Design Discharge	720	m^3/s
Width of Undersluice	5.0	m
Height of Undersluice	5.0	m
Gravitational Acceleration	9.81	m/s^2
Cross sectional Area	25	
Wetted Perimeter	20	
Hydraulic Radius	1.25	
(U/S water level) - (D/S water level) = h	16.40	m

CAPACITY OF UNDER SLUICE

$$X = (1/1+f_i+f_o+f_c+f_{fr})^{\wedge}1/2$$

where

Coefficient for intake losses (f_i)	0.06	
Coefficient for outlet losses (f_o)	1	
Coefficient for change in cross sec. (f_c)	0.04	
Coefficient for friction losses (f_{fr})		
Stickler's coefficient (k)	70	
f_{fr} =	0.13	
X =	0.67	
X		
V = (2gh)^0.5	12.00	m/s
Q = One Under Sluice	**300.0**	m^3/s
Discharge through three Undersluices	**900.1**	m^3/s

According to the control calculations, the capacity of each of the undersluice gates is approximately 270 m^3/s. The discharge capacity calculation, which depends on many assumptions, is correct. It is recommended to conduct a model test to verify the effect of the gates on each other and the flushing ability of the undersluice system.

Since the gated under sluice section of the spillway will work together with the uncontrolled ogee shaped spillway to evacuate the flood to the downstream, it is of great importance that

the gates are always working. Therefore, reliable energy must be guaranteed for the weir location.

Weir sluice gate operation is vital for sediment flushing and full utilization of energy potential.

Even if geotechnical ground improvements are to be made, it is necessary to pay attention to the division of the structure into blocks in such a way that the possible minimal different settlements and the possible jamming of the gates will be prevented, that is, the caps will remain in a single block.

9.4.3 Freeboard Calculations

- **Wind Speed**

Since there is no wind data available specific to the Attabad Lake HPP region, it is assumed as 100 km/hr with all speed correction factors applied in the Feasibility Study. The calculations and assumptions made are in accordance with the general tendency.

- **Design Wave Height and Duration**

The wind height has been calculated using Molitor - Stevenson Formula as Hs = 1.21 m in the Feasibility report. The adopted crest elevation of the cofferdam is fixed at 2420.0 m.a.s.l. The channel will discharge in free flow condition.

If detailed wind and fetch information is obtained during the application design project phase, more detailed study is recommended.

9.5 DESIGN OF RIVER DIVERSION WORKS

It is suggested to do the construction with stage construction utilizing diversion channels. This method is suitable for such a construction, however, after obtaining detail inputs for mapping, floods and design of weir, river diversion works need to be checked to see if it is appropriate. It can be applied in principle, but should be re-examined with current hydrological data during the application phase.

9.5.1 Discharge Capacity of River Diversion Works

The design flood return period for Attabad Lake HPP has been selected as 20 years in the Feasibility Study. The design of the diversion system in dam-type structures is made using Q25 (with freeboard) and Q50 (without freeboard) flow rates. Q5 (with freeboard) and Q10 (without freeboard) flow rates are used in weir type structures. Attabad Hydropower Facility is in between these two facilities. Therefore, it is reasonable for the designer to use the Q20 flow rate with a freeboard. However, in the next stages, it should also be checked which frequency flow passes without freeboard.

Moreover, it is stated that the cofferdam will be strengthened in case of any possible overtopping. Diversion channel discharge rating has been calculated as given in Table 9.1.

Table 9.1 Diversion channel discharge rating calculations

Geometrical Input Data			Calculation of Downstream Rating Curve						
Length of Canal :	475.00	m	Wat. Dep	Area	Wett.Par	Hydr.Rad.	Discharge	Velocity	Froude No.
Slope Water Side : 1:	1.00	-	m	m^2	m	m	m^3/s	m/s	-
Hydraulic Bed Width :	25.00	m	0.00	0.00	25.00	0.00	0.00	0.00	0.00
Strickler Value (M)	45.00	-	0.40	10.16	26.13	0.39	27.37	2.69	1.36
Slope of Energy Line (S)	6.475	-	0.80	20.64	27.26	0.76	86.71	4.20	1.50
			1.20	31.44	28.39	1.11	170.19	5.41	1.58
Water Depth : (Input)	5.00	m	1.60	42.56	29.53	1.44	274.67	6.45	1.63
Depth : (From rating curve)	5.00	m	2.00	54.00	30.66	1.76	398.33	7.38	1.67
$Q = MxR^{0.667}xS^{0.5}xA$			2.40	65.76	31.79	2.07	539.97	8.21	1.69
Discharge	1857.79	m^3/s	2.80	77.84	32.92	2.36	698.73	8.98	1.71
			3.20	90.24	34.05	2.65	874.02	9.69	1.73
WL Canal Start :	2403.00	m.a.s.l.	3.60	102.96	35.18	2.93	1065.38	10.35	1.74
WL Canal End :	2397.00	m.a.s.l.	4.00	116.00	36.31	3.19	1272.50	10.97	1.75
			4.40	129.36	37.45	3.45	1495.13	11.56	1.76
BL Canal Start :	2398.00	m.a.s.l.	4.80	143.04	38.58	3.71	1733.09	12.12	1.77
BL Canal End :	2392.00	m.a.s.l.	5.00	150.00	39.14	3.83	1857.79	12.39	1.77

Crest level of the cofferdam has been selected as 2421.0 masl allowing 2.0 m freeboard.

Since there is no detailed information in the drawings, the calculations could not be checked. During the detailed design phase, after the final maps are obtained, necessary design studies will be carried out, and controls will be made after the cross sections are obtained.

9.6 POWER INTAKE STRUCTURE

In the Feasibility Study twin intakes have been provided for intake of water into the power waterway system with 30.0 m³/s capacity of each. The invert of the intake is placed at elevation 2412.0 m.a.s.l. based on sediment control and submergence considerations. Deck and other operating levels have been set at 2422.0 m.a.s.l.so that the intake can perform over a range of operating water levels in the reservoir including maximum flood water levels.

The drawing contains slightly different information than report. The water intake drawing and the information about the geometry expressed in the report are inconsistent. The drawing should be harmonized with the design and calculations to be made in the next stage.

9.6.1 Hydraulic Design of Intake

- **Criteria for Design**

Intake structure dimensions and type is suitable in terms of hydraulics.

- **Intake Submergence**

There are also some inconsistencies between drawings and Feasibility Report. Power intake submergence has been calculated with Gordon's relationship for asymmetrical flow in the Feasibility Study and determined as S_{min} = 3.75 m.

The submergence has been calculated as 1.75m. The value calculated in the Feasibility Report is higher than this value. Therefore, after finalizing the intake dimensions during next stages of design, submergence calculation should be renewed.

After the drawing of the water intake is finalized as stated in section 9.7 according to the calculations to be made, it should be ensured that the critical submergence is controlled according to the calculations to be made and the current system.

Critical submergence depth should also be verified by hydraulic model test.

- **Power Intake Settings**

Maximum Operation Level	2414.0 m.a.s.l.
Minimum Operation Level	2412.0 m.a.s.l.
Required submergence	2.0 m
Intake waterway height	4.5 m
Required Invert level	2404.0 m.a.s.l.

The intake invert has been set at 2404.0 m.a.s.l.

Since vortex formation is dependent on many factors including orientation of the intake to flow and not only on submergence, hydraulic model studies are recommended at detailed design stage to confirm that vortices do not form at the intake. Power intake site photograph is given in Figure 9.4.

Figure 9.4: Water Intake Location

- **Trashrack Cross-sectional Area**

The velocity of the water was limited to 1 m/s and a gross trashrack area of 60 square meters was selected. The trashrack grid spacing design, gross and net velocities should be reviewed with the EM equipment supplier.

9.7 LOW PRESSURE TUNNEL

Loss types, formulas, and velocity inside reinforced concrete tunnel limitation are mentioned. 5.5 m tunnel diameter was found as a result of optimization. However, the tunnel diameter given in the drawings is 5.2 m, which is inconsistent with the 5.5 m stated in the report. The tunnel diameter is suitable as the velocity criteria given in concrete lined tunnels are met. In the report, the longitudinal slope of the tunnel is given as 0.4%. In the next design stages, the friction loss calculation together with the local losses should be renewed to ensure that the piezometry does not intersect the tunnel profile and that a safe positive pressure is formed inside the tunnel.

Low pressure tunnel from intake to surge tank would be excavated in the left bank rock formation parallel and at lower elevation to existing highway tunnel. The length of headrace tunnel is estimated about 2320 m. The closest part of the headrace scheme to the KKH Tunnel is at surge tank. At this point, the surge tank bottom elevation is 2385m, whereas the KKH tunnel invert elevation is 2376m. The perpendicular distance between the outer walls of the structures is 65m. Since the geological formation is defined as moderately weathered gneiss in the as-built drawings of the KKH tunnel, the interaction between the structures is regarded as safe.

The biggest portion of the underground works is the excavation of the headrace tunnel, which is approximately 2.3 km long. The headrace tunnel covers about 95% of the total underground works excavation volume.

Headrace tunnel was optimized by considering different diameters for design discharge of 60 m^3/s.

The optimized diameter of low pressure headrace tunnel is 5.5m and its length 2320m. The upstream level of tunnel is El. 2,402.5 masl whereas downstream level is El. 2,385 masl.

The proposed alignment for tunnel is generally fine with overburden surface cover along some locations which can be further investigated for sub surface rock cover during detail design investigations by EPC contractor.

In the Feasibility Report, the geological profile of the low pressure tunnel and proposed construction methodology and support systems are missing, hence, the quantities used in the cost estimates could not be verified. Typical support systems and their application changes shall be evaluated further to reach a more sound cost estimate.

The measures to be taken at the fault zone which the low pressure tunnel is passing through shall be clarified and incorporated in the tender design.

The data for existing KKH road tunnels alignment, elevation and geological profile is important for the design of new tunnel to arrive at a practical and safe design for its construction.

In addition to low pressure tunnel itself, the two (02) adits (access tunnels) reaching the power intake section and surge tank section that are about 450 and 202 meters long respectively shall be elaborated further. The cross sections, supports systems and geological profiles of adits need to be incorporated to the tender design of EPC documents.

In case of any other alternative layout scheme of the hydropower project that requires a tunnel arrangement, the geological longitudinal profile, cross section and provisional support systems need to be added to the tender design of EPC documents.

9.8 SURGE TANK

Throttled cylindrical surge tank has been selected during the Feasibility Study. The cross sectional area of the cylindrical surge tank is selected with a factor of safety of 2.5 times larger than the Thoma-Criterion to ensure adequate stability of plant operation.

Choosing the throttled surge tank is appropriate in terms of minimizing the energy tunnel losses during energy production. Photograph of Surge Tank location and Penstock alignments is shown in Figure 9.5.

Figure 9.5: Penstock and Surge Tank Location

9.8.1 Hydraulic Design of Surge Tank

Main features of Surge Tank hydraulic design are summarized in Table 9.2.

Table 9.2 Minimum Cross Section for Surge Tank at Headrace Tunnel

Total headrace discharge	Q	60	m^3/s
Length of headrace tunnel	L	2320	m
Diameter of Tunnel	D	5.50	m
Cross section area	A	24.62	m^2
Head loss	h	2.6	m
Velocity in tunnel	v	2.46	m/s
Velocity head	$v^2/2g$	0.31	m
Minimum reservoir level	W_L	2412.0	m.a.s.l
Minimum tailwater level	W_L	2302.0	m.a.s.l
Head difference	H_o	110.0	m
Net head	H_n	105.2	m
	A_S	63.16	m^2
	1.5 A_S	90.08	
	$D_{Ssquared}$	10.7	m
	$D_{Sselected}$	10.0	m

Following scenarios have been assumed for the design of the surge tank:

LC-UP 1) Load acceptance from partial load, not exceeding 50 % total load increase; subsequent full load rejection;

LC-UP 2) Load acceptance of two units after synchronization; subsequent full load rejection;

LC-DN 1) Full load acceptance of two turbines followed by another turbine after a certain time interval

LC-DN 2) Load reduction by 50 per cent and subsequent complete load acceptance.

Calculations for turbine load acceptance, turbine load rejection durations and valve opening-closing durations will be repeated with the exact durations after the E/M manufacturer is determined.

Some investors/clients also want to study successive opening-closing, reopening-reclosing scenarios, therefore additional scenarios can be added to the surge tank design within the scope of this project.

9.8.2 Load Case Maximum Upsurge

This load case represents the most unfavorable moment for upsurge which is full load rejection when the headrace tunnel is at its maximum. Following assumptions and scenarios are made in the Feasibility Study for maximum upsurge:

Turbine load acceptance after synchronization		5.0 seconds (10 to100%)
Wicket gate closure at turbine load rejection :		5.0 seconds (100 to 0 %)
Maximum Reservoir Level	:	2414.0 m.a.s.l.
Minimum tunnel roughness	:	0.3 mm

LC-UP 1)	Load acceptance from partial load, not exceeding 50 % total load increase; subsequent full load rejection;
LC-UP 2)	Load acceptance of two units after synchronization; subsequent full load rejection;
LC-DN 1)	Full load acceptance of two turbines followed by another turbine after a certain time interval
LC-DN 2)	Load reduction by 50 per cent and subsequent complete load acceptance.

A conservative approach is taken in the present feasibility design, full load acceptance of two units connected to the headrace tunnel will be assumed as extraordinary load case for which the surge tank design shall guarantee the specified minimum freeboard margins. Following assumptions are made in the Feasibility Study for minimum down surge:

Turbine load acceptance after synchronization	50 sec (10-100%)
Wicket gate closure at turbine load rejection	5.0 sec (100-0%)
Minimum reservoir water level	2412.0 m.a.s.l.
Maximum turbine discharge	20 m^3/s
Maximum tunnel roughness	0.3 mm

Water level variation and Discharge variation is presented in Figure 9.6 and Figure 9.7 respectively.

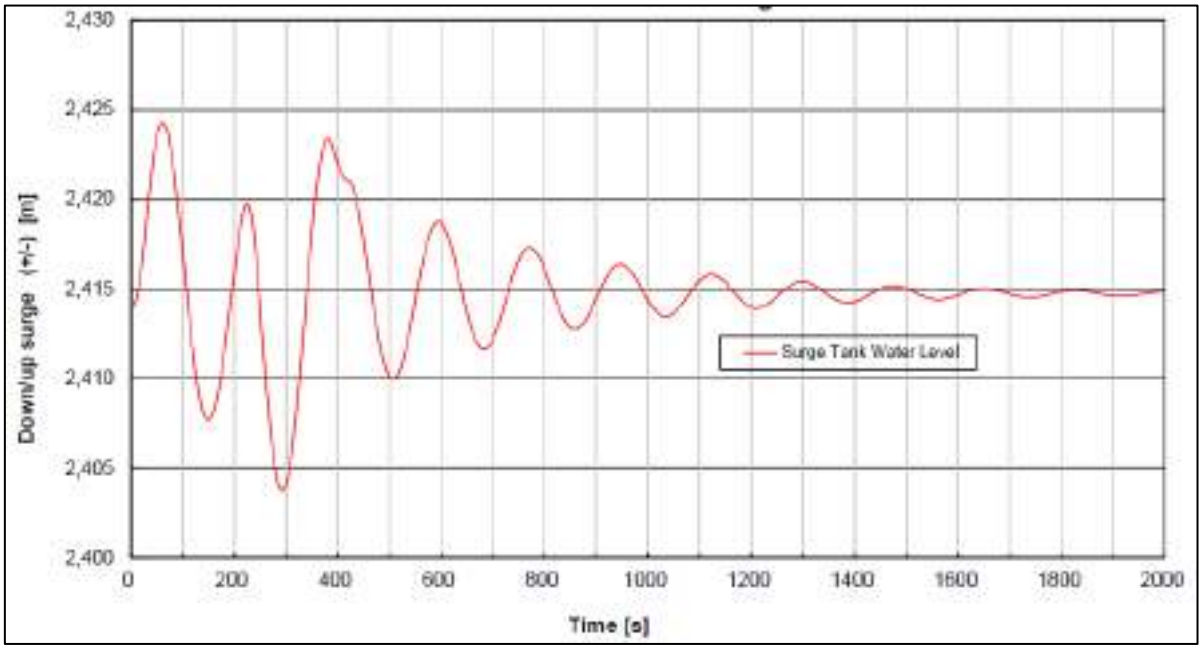


Figure 9.6: Water Level Variation in Surge Tank

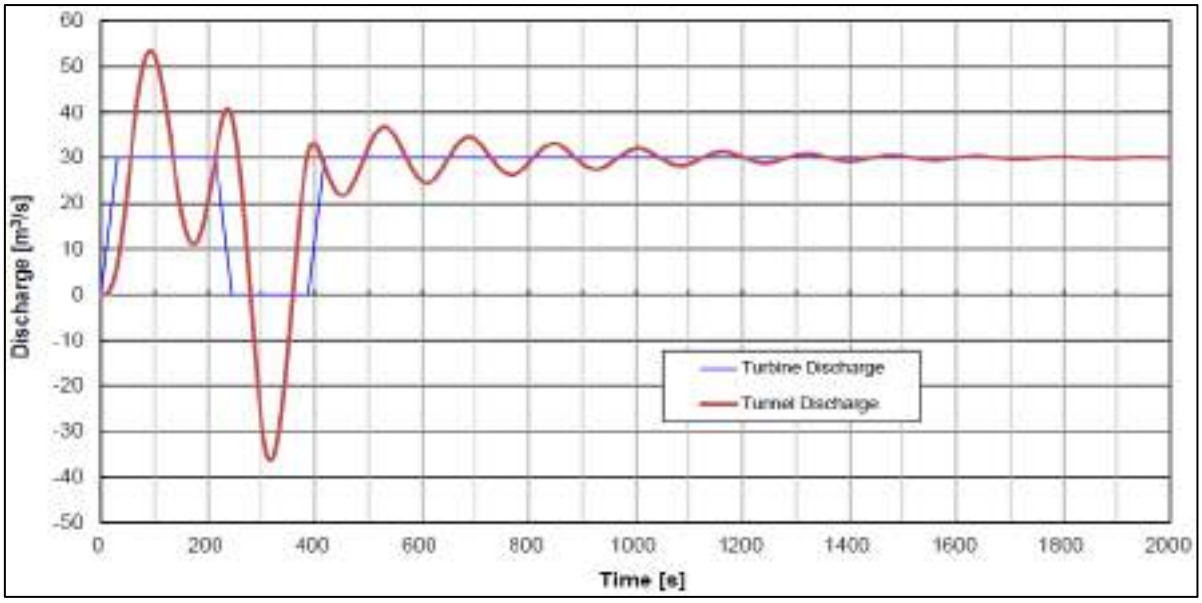


Figure 9.7: Discharge Variation in Surge Tank

During the examination of upsurge and downsurge conditions, an initial elevation should be used for T=0 sec, taking into account the losses in the conveyance system and the maximum and minimum water elevations of the reservoir. For downsurge, minimum water level and maximum system discharge (for 3 turbines) and on-off scenarios should be used while the system is stopped. For Upsurge, calculations should be made in case of sudden load rejection of 3 turbines operating at maximum flow rate at the maximum elevation of the reservoir. In this case, the losses should be taken into account when determining the initial level of the surge tank. In other words, it is not a correct approach to take the direct reservoir water level inside the surge tank. Upsurge and downsurge graphs should be determined by the EM equipment manufacturer for various operating and accident scenarios and given as separate graphs.

9.8.3 Results of Surge Tank Simulation

The results of this analysis is given in the Feasibility Study as follows:

Upsurge	2424.2 m.a.s.l
Down Surge	2403.8 m.a.s.l

In the control analyses made, it has been found that the upsurge and down surge calculations given in the report for the opening and closing of a single unit are correct. However, depending on the client's operation criteria, the opening or closing of more than one unit at the same time may occur in the system. Therefore, during the implementation project phase, the operating scenarios should be decided together with the EM supplier and the client, and the calculations should be renewed depending on the system design criteria. Cases of simultaneous opening or closing of 3 units based on past experience should also be included in the design.

9.9 WATER HAMMER ANALYSIS IN PENSTOCKS

For the water hammer analysis following conditions are used.

Reservoir Level	2414.0 m.a.s.l.
Turbines centre line level	2300.0 m.a.s.l.
Operation Mode	Full Load Rejection within 5 seconds
QT for single unit	20.0 m³/s

Due to the newly proposed location of the powerhouse, the shortening of the penstock will reduce the water hammer effect.

Since some investors do not want the water in the tunnel to flow towards the power plant and cause more damage in case of possible penstock damage, they prefer to put a butterfly valve for emergency response purposes at the first point where the penstock comes to the surface after the surge tank. In case it is decided to add such a valve, necessary precautions should be taken to prevent the penstock from buckling due to negative internal pressure. Accordingly, the drawings of a project implemented in Turkey are given in Figure 9.6 and Figure 9.7.

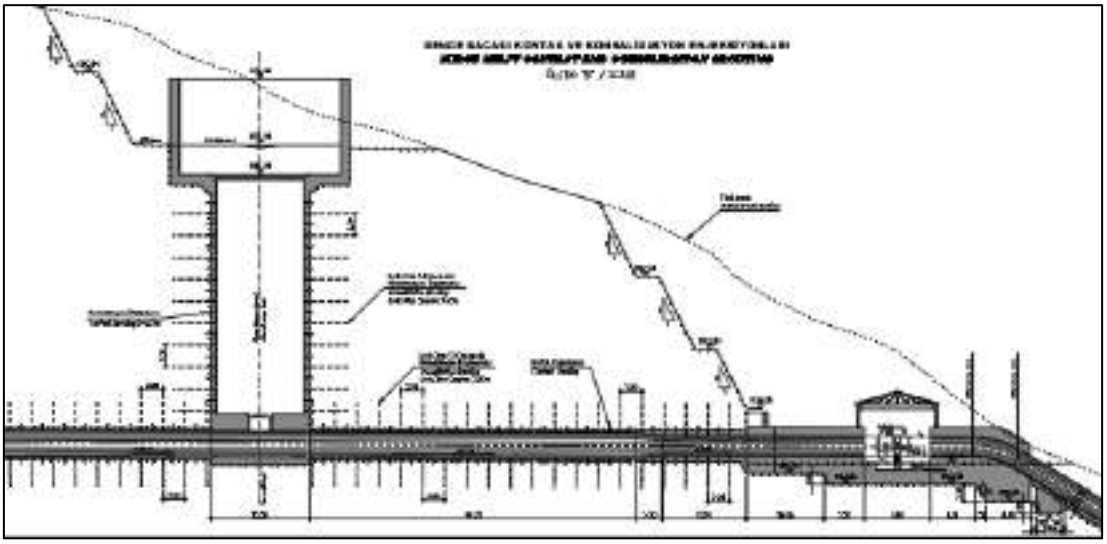


Figure 9.8: Emergency Butterfly Valve after Surge Tank 1/2

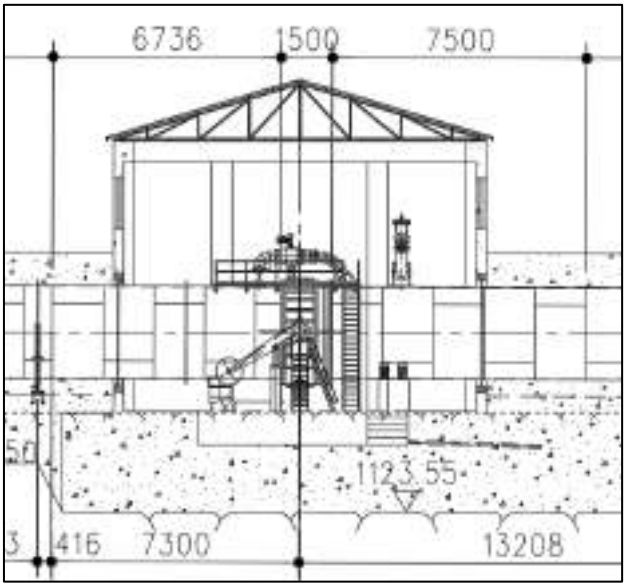


Figure 9.9: Emergency Butterfly Valve after Surge Tank 2/2

9.9.1 Water Hammer Calculations for Single Penstock

In Attabad Hydropower Project the power house has three turbine units. Each turbine unit is connecting with one penstock. To calculate water hammer pressure in the penstocks the longest penstock is considered because it will give the maximum rise in pressure when valve of turbine closed suddenly. The longest penstock is 35m long.

Total discharge for 3 units	Q	= 60.0 m^3/s
Discharge for single turbine	QT	= 20.0 m^3/s
Diameter of penstock	D	= 2.07 m
Velocity in the penstock	V	= 5.89 m/s
Length of penstock	L	= 35 m
Maximum Operation Level		= 2414.0 m.a.s.l.
Minimum Tail Water Level		= 2300.0 m.a.s.l.
Maximum Head		= 114 m
Steel liner Thickness	t	= 25 mm
D/t		= 82.8

9.9.2 Pressure Wave Velocity

Following Parmakian (1955) formula is used to calculate the velocity of pressure wave in the Feasibility Study:

$$a = \sqrt{\frac{1}{\rho\left(\frac{1}{K} + \frac{DC_1}{Et}\right)}}$$

Where

E = Elastic modulus for steel = $1x10^9$ N/m^2

K = Volume modulus of water = $2.1x10^{11}$ N/m^2

ρ = Mass of water = 1000 kg/m^3

$C_1 = 1-u^2$

u = Poisson's ratio for steel = 0.3

a = 140 m/s

9.9.3 Water Hammer Pressure (Allievi Chart)

Maximum pressure has been calculate as $H_0 + h_{max}$ = 107.6 m in the Feasibility study. Therefore, the pressure rise in the penstock for sudden closure of value (5 s) is 33.02 m. If the powerhouse is brought back closer to the hill, then the length of penstock will be decreased which will result in a decrease in water hammer.

The water hammer calculations should be renewed by the mechanical engineer by using the scenarios expressed in the surge tank design according to the new location of the power plant and therefore the new penstock length.

9.10 POWERHOUSE

There are contradictions between the elevations specified in the powerhouse drawings and the elevations specified in the report. Other dimensions and elevations are given, but should be revised according to the detailed design data to be obtained from the turbine manufacturer. Possible changes in elevations according to the new location of the power plant should be considered in the next design.

Feasibility stage proposed Powerhouse location site photographs are given in Figure 9.8 and Figure 9.9.

Figure 9.10: Feasibility stage Proposed Powerhouse Location 1/2

Figure 9.11: Feasibility stage Proposed Powerhouse Location 2/2

9.11 TAILRACE CHANNEL

From the new powerhouse location, it will be possible to connect the powerhouse to the stream bed with a tail water channel without any change in the installed power of the power plant with a channel of suitable cross-section. However, this design is also associated with the submergence required by the EM equipment

10 REVIEW OF GEOTECHNICAL AND STRUCTURAL STABILITY ANALYSIS

10.1 REVIEW OF SLOPE STABILITY ANALYSIS

The proposed cut slopes for the project components including the Weir have been analysed using GEOSTUDIO suite SLOPE/W.

The design parameters used in the slope stability analysis during Feasibility study are given in Table 10.1.

Table 10.1 Material parameters used for Feasibility study Slope Stability Analysis

Condition	Unit Weight (Kn/m^3)	Cohesion (KPa)	Angle of Internal Friction (Deg)
Below Water Surface	21	100	20
Above Water Surface	18	120	25

Young's Modulus of Elasticity is 1.29 e +4 and poisons ratio used is 0.15.

Slope stability analysis was performed at Feasibility stage to check the stability of right and left side slopes of weir cross-section only at RD 0+50. It must be noted that all the area along the longitudinal section of Weir is slide prone. Therefore, stability of slopes along the length of Weir area should be analyzed, or at least the deepest excavation slopes (RD 0+350) for both sides must be analyzed. This should be done even if flexible gabion mattress as discussed in section on modified project layout is to be provided with some minimal cut slopes on existing natural Spillway.

Although the Feasibility study stability analyses show that the proposed slope angle is stable for the used parameters it is proposed to carry out a sensitivity/back analysis for justification of the geotechnical parameters to be considered in the slope stability calculations especially for the right bank.

The variability of slided material along with large boulders present in the slided mass also necessitate a sensitivity/back analysis for justification of the geotechnical parameters to be considered. Both on the right and left banks, there is a risk is to disturb the sliding material during excavation which will result in higher excavation volumes.

10.2 REVIEW OF SEEPAGE ANALYSIS

Seepage analysis is performed to analyze the Weir structure against uplift and piping using permeability values of stabilized soil blanket and slided mass. For the slided mass two different permeability values are provided at same elevation. It is reported in the Feasibility report that permeability for slided mass was used from in-situ permeability of boreholes. Boreholes 1 and 2 located at the Weir site have irregular permeability values which also do not match with the input permeability values used in seepage analysis. Also, the laboratory test results for the permeability values for stabilized soil is missing from the laboratory testing report. Therefore, the input permeability values of stabilized soil and slided material are uncertain.

11 REVIEW OF HYDROMECHANICAL EQUIPMENT STUDIES

11.1 TURBINE

11.1.1 Turbine Selection Criteria

Indian standards IS 12837 - 1989 and IS 12800 (Part 3) 1991 are mentioned under clause 11.6.1.Therefore, MC recommend to replace these with: i) United States Bureau of Reclamation (USBR) Engineering Monograph no. 20, Selecting Hydraulic Reaction Turbines. ii) ASME guide for Hydropower Mechanical Design.

11.1.2 Type, Rated Speed & Setting

Vertical shaft Francis turbines selected in the feasibility study report (FSR) are best suited for the range of heads available for Attabad lake hydropower project. Chosen synchronous speed of 375 rpm seems appropriate, however, discrepancy found with regard to setting of the turbine. Setting of -1.5m and -2m is mentioned at different places in the report. We endorse the value of -2m below minimal tail water level.

Under clause 11.6.9, the feasibility study states that the turbines will be directly coupled to the generator rotor. Also, in clause 9.11.1 it is stated that the vertical axis Francis turbine is coupled directly to a generator. These statements confuse the reader as if there will be no turbine shaft, however, under clause 11.9 it is evident that each turbine will have its shaft. We concur with the statement of clause 11.9 and clarify that there will be two shafts one for turbine and one for generator.

11.1.3 Turbine Shaft

Under clause 11.9.2, Indian Standard is specified for turbine shaft. MC recommend to replace it with ASTM A668 Class D standard, also material of both turbine and generator shafts shall be the same.

11.1.4 Air Admission System for Aeration against Pressure Pulsation and Vortexes

Generally, the turbines should operate without aeration under all operating conditions, however, turbines may have to operate continuously for long time at part-load conditions. In order to be able to aerate the turbine, if required, aeration-taps will be foreseen for a possible later admission of air to the runner and the draft tube.

11.1.5 Power and Energy Potential

- **Power**

Turbine efficiency considered in the FSR of 91.5% is on lower side. However, MC recommends for EPC Contractor to use it to the order of 93% with confirmation from the manufacturer. 93% Turbine efficiency is well achievable for similar capacity vertical Francis turbines as of Attabad HPP.

Rated head of 106m selected in the FSR for power potential is reasonable, however, it is recommended that EPC contractor should reconfirm it once all the project components are designed and approved by the MC / Employer during detail design phase.

Some of the data / parameters given in the FSR has been rationalized and mentioned hereunder:

The turbine rated output: $P_t = \rho \times g \times Q \times H_n \times \eta_t$

Where;

P_t is turbine output in KW

P is water density at 15°C = 0.999 Kg/m³

g is acceleration due to gravity = 9.8 m/sec²

Q is design unit discharge = 20 m³/sec

H_n is rated net head = 106 m

η_t is turbine efficiency = 93%

P_t = 9.79*20*106*0.93 = 19,300 KW

- **Annual Energy**

Headwater and tailwater ratings along with average daily flow data and head losses have been used for calculating the power, energy and plant factor. Power and annual energy have been worked out using mean of daily flow data for the years 1966 to 2015 and is presented hereunder in Table 11.1.

Table 11.1: Power and Energy Potential

Day	River Flows at Weir (cumecs)	Head Water Level (m)	Flows less Ecological Flows (cumecs)	Plant Peak Discharge (cumecs)	Plant Off-Peak Discharge (cumecs)	No. of Turbines in Operation for Peaking	No. of Turbines in Operation for Off-Peaking	Discharge Per Turbine of Peaking Plant (cumecs)	Discharge Per Turbine of Peaking Plant (cumecs)	Spilled Discharge (cumecs)	Hunza River Flows at PH (cumecs)	TWL (masl)	Gross Head (m)	Head Loss Peaking Plant (m)	Head Loss Off-Peaking Plant (m)	Net Head Peaking Plant (m)	Net Head Off-Peaking Plant (m)	Turb Eff. For Peaking Turbines	Turb Eff. For Peaking Turbines	Peaking Turbines Output (MW)	Off-Peaking Turbines Output (MW)	Peaking Generator Efficiency	Off-Peaking Generator Efficiency	Peaking Generators Output (MW)	Off-Peaking Generators Output (MW)	Peaking Plant Energy at Generator Terminal (GWh)	Off-Peaking Plant Energy at Generator Terminal (GWh)
01-Jan	37.00	2414.00	34.00	60.00	24.00	3	2	20.0	12.0	0.00	34.00	2302.13	111.9	6.000	0.960	105.9	110.9	0.930	0.852	57.83	22.21	0.975	0.967	56.39	21.49	0.226	0.430
02-Jan	36.72	2414.00	33.72	60.00	23.72	3	2	20.0	11.9	0.00	33.72	2302.13	111.9	6.000	0.938	105.9	110.9	0.930	0.848	57.83	21.85	0.975	0.967	56.39	21.13	0.226	0.423
03-Jan	36.45	2413.99	33.45	60.00	23.45	3	2	20.0	11.7	0.00	33.45	2302.13	111.9	6.000	0.916	105.9	110.9	0.930	0.844	57.83	21.50	0.975	0.966	56.39	20.78	0.226	0.416
04-Jan	36.25	2413.99	33.25	60.00	23.25	3	2	20.0	11.6	0.00	33.25	2302.13	111.9	6.000	0.901	105.9	111.0	0.930	0.841	57.83	21.24	0.975	0.966	56.39	20.52	0.226	0.410
05-Jan	35.70	2413.99	32.70	60.00	22.70	3	2	20.0	11.4	0.00	32.70	2302.13	111.9	6.000	0.859	105.9	111.0	0.930	0.833	57.83	20.55	0.975	0.965	56.39	19.84	0.226	0.397
06-Jan	35.68	2413.99	32.68	60.00	22.68	3	2	20.0	11.3	0.00	32.68	2302.13	111.9	6.000	0.857	105.9	111.0	0.930	0.833	57.83	20.52	0.975	0.965	56.39	19.81	0.226	0.396
07-Jan	36.05	2413.99	33.05	60.00	23.05	3	2	20.0	11.5	0.00	33.05	2302.13	111.9	6.000	0.885	105.9	111.0	0.930	0.838	57.83	20.99	0.975	0.966	56.39	20.27	0.226	0.405
08-Jan	35.67	2413.99	32.67	60.00	22.67	3	2	20.0	11.3	0.00	32.67	2302.13	111.9	6.000	0.857	105.9	111.0	0.930	0.833	57.83	20.51	0.975	0.965	56.39	19.80	0.226	0.396
09-Jan	35.47	2413.99	32.47	60.00	22.47	3	2	20.0	11.2	0.00	32.47	2302.13	111.9	6.000	0.842	105.9	111.0	0.930	0.829	57.83	20.26	0.975	0.965	56.39	19.55	0.226	0.391
10-Jan	35.27	2413.99	32.27	60.00	22.27	3	2	20.0	11.1	0.00	32.27	2302.13	111.9	6.000	0.826	105.9	111.0	0.930	0.826	57.83	20.00	0.975	0.965	56.39	19.30	0.226	0.386
11-Jan	35.06	2413.99	32.06	60.00	22.06	3	2	20.0	11.0	0.00	32.06	2302.13	111.9	6.000	0.811	105.9	111.0	0.930	0.823	57.83	19.74	0.975	0.965	56.38	19.04	0.226	0.381
12-Jan	34.98	2413.99	31.98	60.00	21.98	3	2	20.0	11.0	0.00	31.98	2302.13	111.9	6.000	0.805	105.9	111.1	0.930	0.822	57.83	19.64	0.975	0.964	56.38	18.95	0.226	0.379
13-Jan	34.80	2413.99	31.80	60.00	21.80	3	2	20.0	10.9	0.00	31.80	2302.13	111.9	6.000	0.792	105.9	111.1	0.930	0.819	57.83	19.43	0.975	0.964	56.38	18.73	0.226	0.375
14-Jan	34.66	2413.98	31.66	60.00	21.66	3	2	20.0	10.8	0.00	31.66	2302.12	111.9	6.000	0.782	105.9	111.1	0.930	0.817	57.83	19.25	0.975	0.964	56.38	18.55	0.226	0.371
15-Jan	34.43	2413.98	31.43	60.00	21.43	3	2	20.0	10.7	0.00	31.43	2302.12	111.9	6.000	0.766	105.9	111.1	0.930	0.814	57.83	18.97	0.975	0.964	56.38	18.28	0.226	0.366
16-Jan	34.20	2413.98	31.20	60.00	21.20	3	2	20.0	10.6	0.00	31.20	2302.12	111.9	6.000	0.749	105.9	111.1	0.930	0.810	57.83	18.68	0.975	0.963	56.38	18.00	0.226	0.360
17-Jan	34.06	2413.98	31.06	60.00	21.06	3	2	20.0	10.5	0.00	31.06	2302.12	111.9	6.000	0.739	105.9	111.1	0.930	0.808	57.83	18.52	0.975	0.963	56.38	17.84	0.226	0.357
18-Jan	33.84	2413.98	30.84	60.00	20.84	3	2	20.0	10.4	0.00	30.84	2302.12	111.9	6.000	0.724	105.9	111.1	0.930	0.805	57.83	18.26	0.975	0.963	56.38	17.58	0.226	0.352
19-Jan	33.68	2413.98	30.68	60.00	20.68	3	2	20.0	10.3	0.00	30.68	2302.12	111.9	6.000	0.713	105.9	111.1	0.930	0.802	57.83	18.06	0.975	0.962	56.38	17.38	0.226	0.348
20-Jan	33.71	2413.98	30.71	60.00	20.71	3	2	20.0	10.4	0.00	30.71	2302.12	111.9	6.000	0.715	105.9	111.1	0.930	0.803	57.83	18.09	0.975	0.962	56.38	17.42	0.226	0.348
21-Jan	33.63	2413.98	30.63	60.00	20.63	3	2	20.0	10.3	0.00	30.63	2302.12	111.9	6.000	0.709	105.9	111.1	0.930	0.802	57.83	18.00	0.975	0.962	56.38	17.32	0.226	0.346
22-Jan	33.34	2413.98	30.34	60.00	20.34	3	2	20.0	10.2	0.00	30.34	2302.12	111.9	6.000	0.690	105.9	111.2	0.930	0.797	57.83	17.66	0.975	0.962	56.38	16.99	0.226	0.340
23-Jan	33.13	2413.98	30.13	60.00	20.13	3	2	20.0	10.1	0.00	30.13	2302.12	111.9	6.000	0.675	105.9	111.2	0.930	0.794	57.83	17.40	0.975	0.962	56.38	16.73	0.226	0.335
24-Jan	33.02	2413.98	30.02	60.00	20.02	3	2	20.0	10.0	0.00	30.02	2302.12	111.9	6.000	0.668	105.9	111.2	0.930	0.793	57.83	17.27	0.975	0.961	56.38	16.61	0.226	0.332
25-Jan	33.00	2413.98	30.00	60.00	20.00	3	1	20.0	20.0	0.00	30.00	2302.12	111.9	6.000	0.666	105.9	111.2	0.930	0.930	57.83	19.30	0.975	0.975	56.38	18.80	0.226	0.376
26-Jan	32.89	2413.98	29.89	60.00	19.89	3	1	20.0	19.9	0.00	29.89	2302.12	111.9	6.000	0.659	105.9	111.2	0.930	0.930	57.83	19.30	0.975	0.975	56.38	18.80	0.226	0.376
27-Jan	35.81	2413.99	32.81	60.00	22.81	3	2	20.0	11.4	0.00	32.81	2302.13	111.9	6.000	0.867	105.9	111.0	0.930	0.835	57.83	20.68	0.975	0.966	56.39	19.97	0.226	0.399
28-Jan	34.98	2413.99	31.98	60.00	21.98	3	2	20.0	11.0	0.00	31.98	2302.13	111.9	6.000	0.805	105.9	111.1	0.930	0.822	57.83	19.65	0.975	0.964	56.38	18.95	0.226	0.379
29-Jan	34.14	2413.98	31.14	60.00	21.14	3	2	20.0	10.6	0.00	31.14	2302.12	111.9	6.000	0.745	105.9	111.1	0.930	0.809	57.83	18.62	0.975	0.963	56.38	17.93	0.226	0.359
30-Jan	33.36	2413.98	30.36	60.00	20.36	3	2	20.0	10.2	0.00	30.36	2302.12	111.9	6.000	0.691	105.9	111.2	0.930	0.798	57.83	17.67	0.975	0.962	56.38	17.00	0.226	0.340
31-Jan	32.87	2413.98	29.87	60.00	19.87	3	1	20.0	19.9	0.00	29.87	2302.12	111.9	6.000	0.658	105.9	111.2	0.930	0.930	57.83	19.30	0.975	0.975	56.38	18.80	0.226	0.376
01-Feb	32.54	2413.97	29.54	60.00	19.54	3	1	20.0	19.5	0.00	29.54	2302.12	111.9	6.000	0.637	105.9	111.2	0.930	0.929	57.83	19.30	0.975	0.975	56.38	18.80	0.226	0.376
02-Feb	32.37	2413.97	29.37	60.00	19.37	3	1	20.0	19.4	0.00	29.37	2302.12	111.9	6.000	0.625	105.9	111.2	0.930	0.929	57.83	19.30	0.975	0.975	56.38	18.80	0.226	0.376
03-Feb	32.26	2413.97	29.26	60.00	19.26	3	1	20.0	19.3	0.00	29.26	2302.12	111.9	6.000	0.618	105.9	111.2	0.930	0.929	57.83	19.30	0.975	0.975	56.38	18.80	0.226	0.376
04-Feb	32.63	2413.97	29.63	60.00	19.63	3	1	20.0	19.6	0.00	29.63	2302.12	111.9	6.000	0.642	105.9	111.2	0.930	0.929	57.83	19.30	0.975	0.975	56.38	18.80	0.226	0.376
05-Feb	32.38	2413.97	29.38	60.00	19.38	3	1	20.0	19.4	0.00	29.38	2302.12	111.9	6.000	0.626	105.9	111.2	0.930	0.929	57.83	19.30	0.975	0.975	56.38	18.80	0.226	0.376
06-Feb	32.15	2413.97	29.15	60.00	19.15	3	1	20.0	19.2	0.00	29.15	2302.12	111.9	6.000	0.611	105.9	111.2	0.930	0.929	57.83	19.30	0.975	0.975	56.38	18.80	0.226	0.376
07-Feb	31.99	2413.97	28.99	60.00	18.99	3	1	20.0	19.0	0.00	28.99	2302.11	111.9	6.000	0.601	105.9	111.3	0.930	0.928	57.83	19.21	0.975	0.975	56.38	18.73	0.226	0.375

Day	River Flows at Weir (cumecs)	Head Water Level (m)	Flows less Ecological Flows (cumecs)	Plant Peak Discharge (cumecs)	Plant Off-Peak Discharge (cumecs)	No. of Turbines in Operation for Peaking	No. of Turbines in Operation for Off-Peaking	Discharge Per Turbine of Peaking Plant (cumecs)	Discharge Per Turbine of Peaking Plant (cumecs)	Spilled Discharge (cumecs)	Hunza River Flows at PH (cumecs)	TWL (masl)	Gross Head (m)	Head Loss Peaking Plant (m)	Head Loss Off-Peaking Plant (m)	Net Head Peaking Plant (m)	Net Head Off-Peaking Plant (m)	Turb Eff. For Peaking Turbines	Turb Eff. For Peaking Turbines	Peaking Turbines Output (MW)	Off-Peaking Turbines Output (MW)	Peaking Generator Efficiency	Off-Peaking Generator Efficiency	Peaking Generators Output (MW)	Off-Peaking Generators Output (MW)	Peaking Plant Energy at Generator Terminal (GWh)	Off-Peaking Plant Energy at Generator Terminal (GWh)
08-Feb	31.86	2413.97	28.86	60.00	18.86	3	1	20.0	18.9	0.00	28.86	2302.11	111.9	6.000	0.593	105.9	111.3	0.930	0.928	57.83	19.07	0.975	0.975	56.38	18.59	0.226	0.372
09-Feb	31.81	2413.97	28.81	60.00	18.81	3	1	20.0	18.8	0.00	28.81	2302.11	111.9	6.000	0.590	105.9	111.3	0.930	0.928	57.83	19.02	0.975	0.975	56.38	18.54	0.226	0.371
10-Feb	31.68	2413.97	28.68	60.00	18.68	3	1	20.0	18.7	0.00	28.68	2302.11	111.9	6.000	0.582	105.9	111.3	0.930	0.928	57.83	18.89	0.975	0.975	56.38	18.41	0.226	0.368
11-Feb	31.52	2413.97	28.52	60.00	18.52	3	1	20.0	18.5	0.00	28.52	2302.11	111.9	6.000	0.572	105.9	111.3	0.930	0.928	57.83	18.72	0.975	0.975	56.38	18.25	0.226	0.365
12-Feb	31.38	2413.97	28.38	60.00	18.38	3	1	20.0	18.4	0.00	28.38	2302.11	111.9	6.000	0.563	105.9	111.3	0.930	0.928	57.83	18.57	0.975	0.975	56.38	18.11	0.226	0.362
13-Feb	31.33	2413.97	28.33	60.00	18.33	3	1	20.0	18.3	0.00	28.33	2302.11	111.9	6.000	0.560	105.9	111.3	0.930	0.927	57.83	18.53	0.975	0.975	56.38	18.06	0.226	0.361
14-Feb	31.22	2413.97	28.22	60.00	18.22	3	1	20.0	18.2	0.00	28.22	2302.11	111.9	6.000	0.553	105.9	111.3	0.930	0.927	57.83	18.41	0.975	0.975	56.38	17.94	0.226	0.359
15-Feb	31.05	2413.97	28.05	60.00	18.05	3	1	20.0	18.1	0.00	28.05	2302.11	111.9	6.000	0.543	105.9	111.3	0.930	0.927	57.83	18.24	0.975	0.975	56.38	17.78	0.226	0.356
16-Feb	30.91	2413.96	27.91	60.00	17.91	3	1	20.0	17.9	0.00	27.91	2302.11	111.9	6.000	0.535	105.9	111.3	0.930	0.926	57.83	18.08	0.975	0.975	56.38	17.63	0.226	0.353
17-Feb	30.80	2413.96	27.80	60.00	17.80	3	1	20.0	17.8	0.00	27.80	2302.11	111.9	6.000	0.528	105.9	111.3	0.930	0.926	57.83	17.97	0.975	0.975	56.38	17.52	0.226	0.350
18-Feb	30.92	2413.97	27.92	60.00	17.92	3	1	20.0	17.9	0.00	27.92	2302.11	111.9	6.000	0.535	105.9	111.3	0.930	0.927	57.83	18.09	0.975	0.975	56.38	17.64	0.226	0.353
19-Feb	30.75	2413.96	27.75	60.00	17.75	3	1	20.0	17.7	0.00	27.75	2302.11	111.9	6.000	0.525	105.9	111.3	0.930	0.926	57.83	17.90	0.975	0.975	56.38	17.45	0.226	0.349
20-Feb	30.57	2413.96	27.57	60.00	17.57	3	1	20.0	17.6	0.00	27.57	2302.11	111.9	6.000	0.514	105.9	111.3	0.930	0.925	57.83	17.71	0.975	0.975	56.38	17.26	0.226	0.345
21-Feb	30.37	2413.96	27.37	60.00	17.37	3	1	20.0	17.4	0.00	27.37	2302.11	111.9	6.000	0.503	105.9	111.4	0.930	0.923	57.83	17.48	0.975	0.975	56.38	17.04	0.226	0.341
22-Feb	30.19	2413.96	27.19	60.00	17.19	3	1	20.0	17.2	0.00	27.19	2302.11	111.9	6.000	0.493	105.9	111.4	0.930	0.922	57.83	17.29	0.975	0.975	56.38	16.86	0.226	0.337
23-Feb	30.00	2413.96	27.00	60.00	17.00	3	1	20.0	17.0	0.00	27.00	2302.11	111.9	6.000	0.482	105.9	111.4	0.930	0.921	57.83	17.08	0.975	0.975	56.38	16.65	0.226	0.333
24-Feb	29.81	2413.96	26.81	60.00	16.81	3	1	20.0	16.8	0.00	26.81	2302.11	111.9	6.000	0.471	105.9	111.4	0.930	0.920	57.83	16.87	0.975	0.975	56.38	16.44	0.226	0.329
25-Feb	29.57	2413.96	26.57	60.00	16.57	3	1	20.0	16.6	0.00	26.57	2302.10	111.9	6.000	0.458	105.9	111.4	0.930	0.919	57.83	16.61	0.975	0.974	56.38	16.18	0.226	0.324
26-Feb	29.43	2413.96	26.43	60.00	16.43	3	1	20.0	16.4	0.00	26.43	2302.10	111.9	6.000	0.450	105.9	111.4	0.930	0.918	57.83	16.46	0.975	0.974	56.38	16.03	0.226	0.321
27-Feb	32.51	2413.97	29.51	60.00	19.51	3	1	20.0	19.5	0.00	29.51	2302.12	111.9	6.000	0.635	105.9	111.2	0.930	0.929	57.83	19.30	0.975	0.975	56.38	18.80	0.226	0.376
28-Feb	37.64	2414.00	34.64	60.00	24.64	3	2	20.0	12.3	0.00	34.64	2302.14	111.9	6.000	1.012	105.9	110.9	0.930	0.859	57.83	22.97	0.975	0.968	56.39	22.23	0.226	0.445
29-Feb	0.00	2413.80	0.00	60.00	-10.00	3	0	20.0	0.0	0.00	0.00	2302.00	111.8	6.000	0.167	105.8	111.6	0.930	0.000	57.80	0.00	0.975	0.000	56.35	0.00	0.225	0.000
01-Mar	30.05	2413.96	27.05	60.00	17.05	3	1	20.0	17.0	0.00	27.05	2302.11	111.9	6.000	0.484	105.9	111.4	0.930	0.922	57.83	17.13	0.975	0.975	56.38	16.70	0.226	0.334
02-Mar	29.73	2413.96	26.73	60.00	16.73	3	1	20.0	16.7	0.00	26.73	2302.11	111.9	6.000	0.467	105.9	111.4	0.930	0.920	57.83	16.79	0.975	0.974	56.38	16.36	0.226	0.327
03-Mar	29.62	2413.96	26.62	60.00	16.62	3	1	20.0	16.6	0.00	26.62	2302.11	111.9	6.000	0.460	105.9	111.4	0.930	0.919	57.83	16.66	0.975	0.974	56.38	16.24	0.226	0.325
04-Mar	29.48	2413.96	26.48	60.00	16.48	3	1	20.0	16.5	0.00	26.48	2302.10	111.9	6.000	0.453	105.9	111.4	0.930	0.918	57.83	16.51	0.975	0.974	56.38	16.08	0.226	0.322
05-Mar	29.33	2413.96	26.33	60.00	16.33	3	1	20.0	16.3	0.00	26.33	2302.10	111.9	6.000	0.445	105.9	111.4	0.930	0.918	57.83	16.35	0.975	0.974	56.38	15.93	0.226	0.319
06-Mar	29.93	2413.96	26.93	60.00	16.93	3	1	20.0	16.9	0.00	26.93	2302.11	111.9	6.000	0.478	105.9	111.4	0.930	0.921	57.83	17.00	0.975	0.975	56.38	16.57	0.226	0.331
07-Mar	29.87	2413.96	26.87	60.00	16.87	3	1	20.0	16.9	0.00	26.87	2302.11	111.9	6.000	0.474	105.9	111.4	0.930	0.921	57.83	16.94	0.975	0.975	56.38	16.51	0.226	0.330
08-Mar	29.86	2413.96	26.86	60.00	16.86	3	1	20.0	16.9	0.00	26.86	2302.11	111.9	6.000	0.474	105.9	111.4	0.930	0.921	57.83	16.92	0.975	0.975	56.38	16.49	0.226	0.330
09-Mar	29.74	2413.96	26.74	60.00	16.74	3	1	20.0	16.7	0.00	26.74	2302.11	111.9	6.000	0.467	105.9	111.4	0.930	0.920	57.83	16.79	0.975	0.974	56.38	16.36	0.226	0.327
10-Mar	29.65	2413.96	26.65	60.00	16.65	3	1	20.0	16.7	0.00	26.65	2302.11	111.9	6.000	0.462	105.9	111.4	0.930	0.919	57.83	16.70	0.975	0.974	56.38	16.27	0.226	0.325
11-Mar	29.54	2413.96	26.54	60.00	16.54	3	1	20.0	16.5	0.00	26.54	2302.10	111.9	6.000	0.456	105.9	111.4	0.930	0.919	57.83	16.58	0.975	0.974	56.38	16.15	0.226	0.323
12-Mar	29.50	2413.96	26.50	60.00	16.50	3	1	20.0	16.5	0.00	26.50	2302.10	111.9	6.000	0.454	105.9	111.4	0.930	0.919	57.83	16.53	0.975	0.974	56.38	16.10	0.226	0.322
13-Mar	29.29	2413.96	26.29	60.00	16.29	3	1	20.0	16.3	0.00	26.29	2302.10	111.9	6.000	0.442	105.9	111.4	0.930	0.917	57.83	16.30	0.975	0.974	56.38	15.88	0.226	0.318
14-Mar	29.25	2413.96	26.25	60.00	16.25	3	1	20.0	16.3	0.00	26.25	2302.10	111.9	6.000	0.440	105.9	111.4	0.930	0.917	57.83	16.26	0.975	0.974	56.38	15.84	0.226	0.317
15-Mar	29.13	2413.96	26.13	60.00	16.13	3	1	20.0	16.1	0.00	26.13	2302.10	111.9	6.000	0.434	105.9	111.4	0.930	0.917	57.83	16.13	0.975	0.974	56.38	15.71	0.226	0.314
16-Mar	29.61	2413.96	26.61	60.00	16.61	3	1	20.0	16.6	0.00	26.61	2302.11	111.9	6.000	0.460	105.9	111.4	0.930	0.919	57.83	16.65	0.975	0.974	56.38	16.22	0.226	0.324
17-Mar	29.43	2413.96	26.43	60.00	16.43	3	1	20.0	16.4	0.00	26.43	2302.10	111.9	6.000	0.450	105.9	111.4	0.930	0.918	57.83	16.45	0.975	0.974	56.38	16.03	0.226	0.321

Day	River Flows at Weir (cumecs)	Head Water Level (m)	Flows less Ecological Flows (cumecs)	Plant Peak Discharge (cumecs)	Plant Off-Peak Discharge (cumecs)	No. of Turbines in Operation for Peaking	No. of Turbines in Operation for Off-Peaking	Discharge Per Turbine of Peaking Plant (cumecs)	Discharge Per Turbine of Peaking Plant (cumecs)	Spilled Discharge (cumecs)	Hunza River Flows at PH (cumecs)	TWL (masl)	Gross Head (m)	Head Loss Peaking Plant (m)	Head Loss Off-Peaking Plant (m)	Net Head Peaking Plant (m)	Net Head Off-Peaking Plant (m)	Turb Eff. For Peaking Turbines	Turb Eff. For Peaking Turbines	Peaking Turbines Output (MW)	Off-Peaking Turbines Output (MW)	Peaking Generator Efficiency	Off-Peaking Generator Efficiency	Peaking Generators Output (MW)	Off-Peaking Generators Output (MW)	Peaking Plant Energy at Generator Terminal (GWh)	Off-Peaking Plant Energy at Generator Terminal (GWh)
18-Mar	29.23	2413.96	26.23	60.00	16.23	3	1	20.0	16.2	0.00	26.23	2302.10	111.9	6.000	0.439	105.9	111.4	0.930	0.917	57.83	16.24	0.975	0.974	56.38	15.82	0.226	0.316
19-Mar	29.10	2413.96	26.10	60.00	16.10	3	1	20.0	16.1	0.00	26.10	2302.10	111.9	6.000	0.432	105.9	111.4	0.930	0.916	57.83	16.10	0.975	0.974	56.38	15.68	0.226	0.314
20-Mar	36.43	2413.99	33.43	60.00	23.43	3	2	20.0	11.7	0.00	33.43	2302.13	111.9	6.000	0.915	105.9	110.9	0.930	0.844	57.83	21.48	0.975	0.966	56.39	20.76	0.226	0.415
21-Mar	32.74	2413.97	29.74	60.00	19.74	3	1	20.0	19.7	0.00	29.74	2302.12	111.9	6.000	0.649	105.9	111.2	0.930	0.930	57.83	19.30	0.975	0.975	56.38	18.80	0.226	0.376
22-Mar	31.85	2413.97	28.85	60.00	18.85	3	1	20.0	18.8	0.00	28.85	2302.11	111.9	6.000	0.592	105.9	111.3	0.930	0.928	57.83	19.06	0.975	0.975	56.38	18.58	0.226	0.372
23-Mar	30.83	2413.96	27.83	60.00	17.83	3	1	20.0	17.8	0.00	27.83	2302.11	111.9	6.000	0.530	105.9	111.3	0.930	0.926	57.83	17.99	0.975	0.975	56.38	17.54	0.226	0.351
24-Mar	30.06	2413.96	27.06	60.00	17.06	3	1	20.0	17.1	0.00	27.06	2302.11	111.9	6.000	0.485	105.9	111.4	0.930	0.922	57.83	17.14	0.975	0.975	56.38	16.71	0.226	0.334
25-Mar	29.61	2413.96	26.61	60.00	16.61	3	1	20.0	16.6	0.00	26.61	2302.11	111.9	6.000	0.460	105.9	111.4	0.930	0.919	57.83	16.65	0.975	0.974	56.38	16.22	0.226	0.324
26-Mar	29.36	2413.96	26.36	60.00	16.36	3	1	20.0	16.4	0.00	26.36	2302.10	111.9	6.000	0.446	105.9	111.4	0.930	0.918	57.83	16.38	0.975	0.974	56.38	15.95	0.226	0.319
27-Mar	29.30	2413.96	26.30	60.00	16.30	3	1	20.0	16.3	0.00	26.30	2302.10	111.9	6.000	0.443	105.9	111.4	0.930	0.918	57.83	16.32	0.975	0.974	56.38	15.90	0.226	0.318
28-Mar	29.26	2413.96	26.26	60.00	16.26	3	1	20.0	16.3	0.00	26.26	2302.10	111.9	6.000	0.441	105.9	111.4	0.930	0.917	57.83	16.27	0.975	0.974	56.38	15.85	0.226	0.317
29-Mar	29.38	2413.96	26.38	60.00	16.38	3	1	20.0	16.4	0.00	26.38	2302.10	111.9	6.000	0.447	105.9	111.4	0.930	0.918	57.83	16.40	0.975	0.974	56.38	15.98	0.226	0.320
30-Mar	29.48	2413.96	26.48	60.00	16.48	3	1	20.0	16.5	0.00	26.48	2302.10	111.9	6.000	0.453	105.9	111.4	0.930	0.919	57.83	16.51	0.975	0.974	56.38	16.09	0.226	0.322
31-Mar	29.76	2413.96	26.76	60.00	16.76	3	1	20.0	16.8	0.00	26.76	2302.11	111.9	6.000	0.468	105.9	111.4	0.930	0.920	57.83	16.82	0.975	0.974	56.38	16.39	0.226	0.328
01-Apr	29.79	2413.96	26.79	60.00	16.79	3	1	20.0	16.8	0.00	26.79	2302.11	111.9	6.000	0.470	105.9	111.4	0.930	0.920	57.83	16.84	0.975	0.974	56.38	16.41	0.226	0.328
02-Apr	29.92	2413.96	26.92	60.00	16.92	3	1	20.0	16.9	0.00	26.92	2302.11	111.9	6.000	0.477	105.9	111.4	0.930	0.921	57.83	16.99	0.975	0.975	56.38	16.56	0.226	0.331
03-Apr	30.19	2413.96	27.19	60.00	17.19	3	1	20.0	17.2	0.00	27.19	2302.11	111.9	6.000	0.492	105.9	111.4	0.930	0.922	57.83	17.29	0.975	0.975	56.38	16.85	0.226	0.337
04-Apr	30.44	2413.96	27.44	60.00	17.44	3	1	20.0	17.4	0.00	27.44	2302.11	111.9	6.000	0.507	105.9	111.3	0.930	0.924	57.83	17.56	0.975	0.975	56.38	17.12	0.226	0.342
05-Apr	30.65	2413.96	27.65	60.00	17.65	3	1	20.0	17.7	0.00	27.65	2302.11	111.9	6.000	0.519	105.9	111.3	0.930	0.925	57.83	17.80	0.975	0.975	56.38	17.35	0.226	0.347
06-Apr	31.30	2413.97	28.30	60.00	18.30	3	1	20.0	18.3	0.00	28.30	2302.11	111.9	6.000	0.558	105.9	111.3	0.930	0.927	57.83	18.49	0.975	0.975	56.38	18.03	0.226	0.361
07-Apr	32.04	2413.97	29.04	60.00	19.04	3	1	20.0	19.0	0.00	29.04	2302.11	111.9	6.000	0.604	105.9	111.3	0.930	0.929	57.83	19.26	0.975	0.975	56.38	18.78	0.226	0.376
08-Apr	32.54	2413.97	29.54	60.00	19.54	3	1	20.0	19.5	0.00	29.54	2302.12	111.9	6.000	0.636	105.9	111.2	0.930	0.929	57.83	19.30	0.975	0.975	56.38	18.80	0.226	0.376
09-Apr	33.12	2413.98	30.12	60.00	20.12	3	2	20.0	10.1	0.00	30.12	2302.12	111.9	6.000	0.675	105.9	111.2	0.930	0.794	57.83	17.39	0.975	0.962	56.38	16.73	0.226	0.335
10-Apr	33.58	2413.98	30.58	60.00	20.58	3	2	20.0	10.3	0.00	30.58	2302.12	111.9	6.000	0.706	105.9	111.2	0.930	0.801	57.83	17.94	0.975	0.962	56.38	17.26	0.226	0.345
11-Apr	34.16	2413.98	31.16	60.00	21.16	3	2	20.0	10.6	0.00	31.16	2302.12	111.9	6.000	0.746	105.9	111.1	0.930	0.810	57.83	18.64	0.975	0.963	56.38	17.95	0.226	0.359
12-Apr	34.76	2413.99	31.76	60.00	21.76	3	2	20.0	10.9	0.00	31.76	2302.13	111.9	6.000	0.789	105.9	111.1	0.930	0.819	57.83	19.38	0.975	0.964	56.38	18.68	0.226	0.374
13-Apr	35.32	2413.99	32.32	60.00	22.32	3	2	20.0	11.2	0.00	32.32	2302.13	111.9	6.000	0.830	105.9	111.0	0.930	0.827	57.83	20.07	0.975	0.965	56.39	19.36	0.226	0.387
14-Apr	35.96	2413.99	32.96	60.00	22.96	3	2	20.0	11.5	0.00	32.96	2302.13	111.9	6.000	0.878	105.9	111.0	0.930	0.837	57.83	20.87	0.975	0.966	56.39	20.16	0.226	0.403
15-Apr	37.17	2414.00	34.17	60.00	24.17	3	2	20.0	12.1	0.00	34.17	2302.13	111.9	6.000	0.974	105.9	110.9	0.930	0.854	57.83	22.41	0.975	0.967	56.39	21.69	0.226	0.434
16-Apr	38.24	2414.00	35.24	60.00	25.24	3	2	20.0	12.6	0.00	35.24	2302.14	111.9	6.000	1.061	105.9	110.8	0.930	0.865	57.83	23.68	0.975	0.969	56.39	22.93	0.226	0.459
17-Apr	39.03	2414.01	36.03	60.00	26.03	3	2	20.0	13.0	0.00	36.03	2302.14	111.9	6.000	1.129	105.9	110.7	0.930	0.873	57.83	24.63	0.975	0.969	56.39	23.88	0.226	0.478
18-Apr	39.60	2414.01	36.60	60.00	26.60	3	2	20.0	13.3	0.00	36.60	2302.14	111.9	6.000	1.179	105.9	110.7	0.930	0.879	57.83	25.32	0.975	0.970	56.39	24.57	0.226	0.491
19-Apr	40.33	2414.01	37.33	60.00	27.33	3	2	20.0	13.7	0.00	37.33	2302.15	111.9	6.000	1.245	105.9	110.6	0.930	0.886	57.83	26.22	0.975	0.971	56.39	25.45	0.226	0.509
20-Apr	41.31	2414.02	38.31	60.00	28.31	3	2	20.0	14.2	0.00	38.31	2302.15	111.9	6.000	1.336	105.9	110.5	0.930	0.894	57.84	27.40	0.975	0.972	56.39	26.62	0.226	0.532
21-Apr	42.77	2414.03	39.77	60.00	29.77	3	2	20.0	14.9	0.00	39.77	2302.16	111.9	6.000	1.477	105.9	110.4	0.930	0.903	57.84	29.05	0.975	0.973	56.39	28.26	0.226	0.565
22-Apr	44.24	2414.03	41.24	60.00	31.24	3	2	20.0	15.6	0.00	41.24	2302.16	111.9	6.000	1.627	105.9	110.2	0.930	0.911	57.84	30.73	0.975	0.974	56.39	29.92	0.226	0.598
23-Apr	45.59	2414.04	42.59	60.00	32.59	3	2	20.0	16.3	0.00	42.59	2302.17	111.9	6.000	1.771	105.9	110.1	0.930	0.917	57.84	32.23	0.975	0.974	56.39	31.40	0.226	0.628
24-Apr	47.71	2414.05	44.71	60.00	34.71	3	2	20.0	17.4	0.00	44.71	2302.18	111.9	6.000	2.008	105.9	109.9	0.930	0.923	57.84	34.48	0.975	0.975	56.39	33.61	0.226	0.672
25-Apr	50.49	2414.07	47.49	60.00	37.49	3	2	20.0	18.7	0.00	47.49	2302.19	111.9	6.000	2.342	105.9	109.5	0.930	0.928	57.84	37.31	0.975	0.975	56.40	36.38	0.226	0.728

Day	River Flows at Weir (cumecs)	Head Water Level (m)	Flows less Ecological Flows (cumecs)	Plant Peak Discharge (cumecs)	Plant Off-Peak Discharge (cumecs)	No. of Turbines in Operation for Peaking	No. of Turbines in Operation for Off-Peaking	Discharge Per Turbine of Peaking Plant (cumecs)	Discharge Per Turbine of Peaking Plant (cumecs)	Spilled Discharge (cumecs)	Hunza River Flows at PH (cumecs)	TWL (masl)	Gross Head (m)	Head Loss Peaking Plant (m)	Head Loss Off-Peaking Plant (m)	Net Head Peaking Plant (m)	Net Head Off-Peaking Plant (m)	Turb Eff. For Peaking Turbines	Turb Eff. For Peaking Turbines	Peaking Turbines Output (MW)	Off-Peaking Turbines Output (MW)	Peaking Generator Efficiency	Off-Peaking Generator Efficiency	Peaking Generators Output (MW)	Off-Peaking Generators Output (MW)	Peaking Plant Energy at Generator Terminal (GWh)	Off-Peaking Plant Energy at Generator Terminal (GWh)
26-Apr	54.49	2414.09	51.49	60.00	41.49	3	3	20.0	13.8	0.00	51.49	2302.20	111.9	6.000	2.869	105.9	109.0	0.930	0.889	57.85	39.38	0.975	0.971	56.40	38.23	0.226	0.765
27-Apr	57.02	2414.10	54.02	60.00	44.02	3	3	20.0	14.7	0.00	54.02	2302.21	111.9	6.000	3.229	105.9	108.7	0.930	0.900	57.85	42.16	0.975	0.972	56.40	40.98	0.226	0.820
28-Apr	59.72	2414.12	56.72	60.00	46.72	3	3	20.0	15.6	0.00	56.72	2302.22	111.9	6.000	3.639	105.9	108.3	0.930	0.911	57.85	45.11	0.975	0.973	56.40	43.90	0.226	0.878
29-Apr	61.67	2414.13	58.67	60.00	48.67	3	3	20.0	16.2	0.00	58.67	2302.23	111.9	6.000	3.948	105.9	107.9	0.930	0.917	57.85	47.17	0.975	0.974	56.40	45.94	0.226	0.919
30-Apr	63.23	2414.133	60.23	60.00	60.00	3	3	20.0	20.0	0.23	60.47	2302.236	111.9	6.000	6.000	105.90	105.9	0.930	0.930	57.85	57.85	0.975	0.975	56.40	56.40	0.226	1.128
01-May	62.54	2414.13	59.54	60.00	49.54	3	3	20.0	16.5	0.00	59.54	2302.23	111.9	6.000	4.091	105.9	107.8	0.930	0.919	57.85	48.04	0.975	0.974	56.40	46.79	0.226	0.936
02-May	63.96	2414.14	60.96	60.00	60.00	3	3	20.0	20.0	0.96	61.93	2302.24	111.9	6.000	6.000	105.9	105.9	0.930	0.930	57.85	57.85	0.975	0.975	56.40	56.40	0.226	1.128
03-May	65.60	2414.15	62.60	60.00	60.00	3	3	20.0	20.0	2.60	65.21	2302.25	111.9	6.000	6.000	105.9	105.9	0.930	0.930	57.85	57.85	0.975	0.975	56.40	56.40	0.226	1.128
04-May	68.38	2414.16	65.38	60.00	60.00	3	3	20.0	20.0	5.38	70.75	2302.28	111.9	6.000	6.000	105.9	105.9	0.930	0.930	57.84	57.84	0.975	0.975	56.40	56.40	0.226	1.128
05-May	73.71	2414.19	70.71	60.00	60.00	3	3	20.0	20.0	10.71	81.41	2302.32	111.9	6.000	6.000	105.9	105.9	0.930	0.930	57.84	57.84	0.975	0.975	56.39	56.39	0.226	1.128
06-May	76.77	2414.20	73.77	60.00	60.00	3	3	20.0	20.0	13.77	87.54	2302.34	111.9	6.000	6.000	105.9	105.9	0.930	0.930	57.83	57.83	0.975	0.975	56.39	56.39	0.226	1.128
07-May	81.48	2414.23	78.48	60.00	60.00	3	3	20.0	20.0	18.48	96.96	2302.37	111.9	6.000	6.000	105.9	105.9	0.930	0.930	57.83	57.83	0.975	0.975	56.38	56.38	0.226	1.128
08-May	86.87	2414.25	83.87	60.00	60.00	3	3	20.0	20.0	23.87	107.74	2302.41	111.8	6.000	6.000	105.8	105.8	0.930	0.930	57.82	57.82	0.975	0.975	56.37	56.37	0.225	1.127
09-May	92.09	2414.28	89.09	60.00	60.00	3	3	20.0	20.0	29.09	118.17	2302.45	111.8	6.000	6.000	105.8	105.8	0.930	0.930	57.81	57.81	0.975	0.975	56.37	56.37	0.225	1.127
10-May	94.32	2414.29	91.32	60.00	60.00	3	3	20.0	20.0	31.32	122.63	2302.47	111.8	6.000	6.000	105.8	105.8	0.930	0.930	57.81	57.81	0.975	0.975	56.36	56.36	0.225	1.127
11-May	95.00	2414.29	92.00	60.00	60.00	3	3	20.0	20.0	32.00	123.99	2302.47	111.8	6.000	6.000	105.8	105.8	0.930	0.930	57.81	57.81	0.975	0.975	56.36	56.36	0.225	1.127
12-May	98.47	2414.31	95.47	60.00	60.00	3	3	20.0	20.0	35.47	130.95	2302.50	111.8	6.000	6.000	105.8	105.8	0.930	0.930	57.80	57.80	0.975	0.975	56.36	56.36	0.225	1.127
13-May	102.49	2414.33	99.49	60.00	60.00	3	3	20.0	20.0	39.49	138.98	2302.53	111.8	6.000	6.000	105.8	105.8	0.930	0.930	57.80	57.80	0.975	0.975	56.35	56.35	0.225	1.127
14-May	108.04	2414.36	105.04	60.00	60.00	3	3	20.0	20.0	45.04	150.08	2302.57	111.8	6.000	6.000	105.8	105.8	0.930	0.930	57.79	57.79	0.975	0.975	56.35	56.35	0.225	1.127
15-May	117.41	2414.41	114.41	60.00	60.00	3	3	20.0	20.0	54.41	168.83	2302.64	111.8	6.000	6.000	105.8	105.8	0.930	0.930	57.78	57.78	0.975	0.975	56.34	56.34	0.225	1.127
16-May	125.00	2414.44	122.00	60.00	60.00	3	3	20.0	20.0	62.00	183.99	2302.69	111.8	6.000	6.000	105.8	105.8	0.930	0.930	57.77	57.77	0.975	0.975	56.33	56.33	0.225	1.127
17-May	129.41	2414.47	126.41	60.00	60.00	3	3	20.0	20.0	66.41	192.82	2302.72	111.7	6.000	6.000	105.7	105.7	0.930	0.930	57.77	57.77	0.975	0.975	56.32	56.32	0.225	1.126
18-May	135.64	2414.50	132.64	60.00	60.00	3	3	20.0	20.0	72.64	205.29	2302.76	111.7	6.000	6.000	105.7	105.7	0.930	0.930	57.76	57.76	0.975	0.975	56.32	56.32	0.225	1.126
19-May	137.53	2414.50	134.53	60.00	60.00	3	3	20.0	20.0	74.53	209.06	2302.78	111.7	6.000	6.000	105.7	105.7	0.930	0.930	57.76	57.76	0.975	0.975	56.31	56.31	0.225	1.126
20-May	140.59	2414.52	137.59	60.00	60.00	3	3	20.0	20.0	77.59	215.17	2302.80	111.7	6.000	6.000	105.7	105.7	0.930	0.930	57.76	57.76	0.975	0.975	56.31	56.31	0.225	1.126
21-May	143.80	2414.54	140.80	60.00	60.00	3	3	20.0	20.0	80.80	221.60	2302.82	111.7	6.000	6.000	105.7	105.7	0.930	0.930	57.75	57.75	0.975	0.975	56.31	56.31	0.225	1.126
22-May	148.08	2414.56	145.08	60.00	60.00	3	3	20.0	20.0	85.08	230.16	2302.85	111.7	6.000	6.000	105.7	105.7	0.930	0.930	57.75	57.75	0.975	0.975	56.30	56.30	0.225	1.126
23-May	156.90	2414.60	153.90	60.00	60.00	3	3	20.0	20.0	93.90	247.80	2302.91	111.7	6.000	6.000	105.7	105.7	0.930	0.930	57.74	57.74	0.975	0.975	56.29	56.29	0.225	1.126
24-May	161.08	2414.62	158.08	60.00	60.00	3	3	20.0	20.0	98.08	256.17	2302.94	111.7	6.000	6.000	105.7	105.7	0.930	0.930	57.73	57.73	0.975	0.975	56.29	56.29	0.225	1.126
25-May	165.74	2414.64	162.74	60.00	60.00	3	3	20.0	20.0	102.74	265.48	2302.97	111.7	6.000	6.000	105.7	105.7	0.930	0.930	57.73	57.73	0.975	0.975	56.28	56.28	0.225	1.126
26-May	165.32	2414.64	162.32	60.00	60.00	3	3	20.0	20.0	102.32	264.63	2302.97	111.7	6.000	6.000	105.7	105.7	0.930	0.930	57.73	57.73	0.975	0.975	56.28	56.28	0.225	1.126
27-May	168.03	2414.65	165.03	60.00	60.00	3	3	20.0	20.0	105.03	270.06	2302.98	111.7	6.000	6.000	105.7	105.7	0.930	0.930	57.73	57.73	0.975	0.975	56.28	56.28	0.225	1.126
28-May	170.22	2414.66	167.22	60.00	60.00	3	3	20.0	20.0	107.22	274.43	2303.00	111.7	6.000	6.000	105.7	105.7	0.930	0.930	57.72	57.72	0.975	0.975	56.28	56.28	0.225	1.126
29-May	177.16	2414.69	174.16	60.00	60.00	3	3	20.0	20.0	114.16	288.32	2303.04	111.7	6.000	6.000	105.7	105.7	0.930	0.930	57.72	57.72	0.975	0.975	56.27	56.27	0.225	1.125
30-May	185.90	2414.73	182.90	60.00	60.00	3	3	20.0	20.0	122.90	305.81	2303.10	111.6	6.000	6.000	105.6	105.6	0.930	0.930	57.71	57.71	0.975	0.975	56.26	56.26	0.225	1.125
31-May	194.18	2414.77	191.18	60.00	60.00	3	3	20.0	20.0	131.18	322.37	2303.15	111.6	6.000	6.000	105.6	105.6	0.930	0.930	57.70	57.70	0.975	0.975	56.26	56.26	0.225	1.125
01-Jun	203.87	2414.82	200.87	60.00	60.00	3	3	20.0	20.0	140.87	341.74	2303.21	111.6	6.000	6.000	105.6	105.6	0.930	0.930	57.69	57.69	0.975	0.975	56.25	56.25	0.225	1.125
02-Jun	213.49	2414.86	210.49	60.00	60.00	3	3	20.0	20.0	150.49	360.97	2303.27	111.6	6.000	6.000	105.6	105.6	0.930	0.930	57.68	57.68	0.975	0.975	56.24	56.24	0.225	1.125
03-Jun	223.75	2414.91	220.75	60.00	60.00	3	3	20.0	20.0	160.75	381.49	2303.34	111.6	6.000	6.000	105.6	105.6	0.930	0.930	57.67	57.67	0.975	0.975	56.23	56.23	0.225	1.125

Day	River Flows at Weir (cumecs)	Head Water Level (m)	Flows less Ecological Flows (cumecs)	Plant Peak Discharge (cumecs)	Plant Off-Peak Discharge (cumecs)	No. of Turbines in Operation for Peaking	No. of Turbines in Operation for Off-Peaking	Discharge Per Turbine of Peaking Plant (cumecs)	Discharge Per Turbine of Peaking Plant (cumecs)	Spilled Discharge (cumecs)	Hunza River Flows at PH (cumecs)	TWL (masl)	Gross Head (m)	Head Loss Peaking Plant (m)	Head Loss Off-Peaking Plant (m)	Net Head Peaking Plant (m)	Net Head Off-Peaking Plant (m)	Turb Eff. For Peaking Turbines	Turb Eff. For Peaking Turbines	Peaking Turbines Output (MW)	Off-Peaking Turbines Output (MW)	Peaking Generator Efficiency	Off-Peaking Generator Efficiency	Peaking Generators Output (MW)	Off-Peaking Generators Output (MW)	Peaking Plant Energy at Generator Terminal (GWh)	Off-Peaking Plant Energy at Generator Terminal (GWh)
04-Jun	235.51	2414.96	232.51	60.00	60.00	3	3	20.0	20.0	172.51	405.02	2303.41	111.6	6.000	6.000	105.6	105.6	0.930	0.930	57.66	57.66	0.975	0.975	56.22	56.22	0.225	1.124
05-Jun	244.36	2415.00	241.36	60.00	60.00	3	3	20.0	20.0	181.36	422.73	2303.46	111.5	6.000	6.000	105.5	105.5	0.930	0.930	57.66	57.66	0.975	0.975	56.21	56.21	0.225	1.124
06-Jun	255.78	2415.05	252.78	60.00	60.00	3	3	20.0	20.0	192.78	445.57	2303.53	111.5	6.000	6.000	105.5	105.5	0.930	0.930	57.65	57.65	0.975	0.975	56.20	56.20	0.225	1.124
07-Jun	272.48	2415.12	269.48	60.00	60.00	3	3	20.0	20.0	209.48	478.96	2303.62	111.5	6.000	6.000	105.5	105.5	0.930	0.930	57.63	57.63	0.975	0.975	56.19	56.19	0.225	1.124
08-Jun	290.15	2415.20	287.15	60.00	60.00	3	3	20.0	20.0	227.15	514.30	2303.72	111.5	6.000	6.000	105.5	105.5	0.930	0.930	57.62	57.62	0.975	0.975	56.18	56.18	0.225	1.124
09-Jun	305.32	2415.26	302.32	60.00	60.00	3	3	20.0	20.0	242.32	544.63	2303.81	111.5	6.000	6.000	105.5	105.5	0.930	0.930	57.61	57.61	0.975	0.975	56.17	56.17	0.225	1.123
10-Jun	315.04	2415.30	312.04	60.00	60.00	3	3	20.0	20.0	252.04	564.08	2303.86	111.4	6.000	6.000	105.4	105.4	0.930	0.930	57.60	57.60	0.975	0.975	56.16	56.16	0.225	1.123
11-Jun	328.60	2415.36	325.60	60.00	60.00	3	3	20.0	20.0	265.60	591.19	2303.93	111.4	6.000	6.000	105.4	105.4	0.930	0.930	57.59	57.59	0.975	0.975	56.15	56.15	0.225	1.123
12-Jun	346.03	2415.43	343.03	60.00	60.00	3	3	20.0	20.0	283.03	626.06	2304.02	111.4	6.000	6.000	105.4	105.4	0.930	0.930	57.58	57.58	0.975	0.975	56.14	56.14	0.225	1.123
13-Jun	357.49	2415.47	354.49	60.00	60.00	3	3	20.0	20.0	294.49	648.99	2304.08	111.4	6.000	6.000	105.4	105.4	0.930	0.930	57.58	57.58	0.975	0.975	56.14	56.14	0.225	1.123
14-Jun	362.55	2415.49	359.55	60.00	60.00	3	3	20.0	20.0	299.55	659.10	2304.10	111.4	6.000	6.000	105.4	105.4	0.930	0.930	57.57	57.57	0.975	0.975	56.13	56.13	0.225	1.123
15-Jun	373.63	2415.54	370.63	60.00	60.00	3	3	20.0	20.0	310.63	681.26	2304.16	111.4	6.000	6.000	105.4	105.4	0.930	0.930	57.57	57.57	0.975	0.975	56.13	56.13	0.225	1.123
16-Jun	384.26	2415.58	381.26	60.00	60.00	3	3	20.0	20.0	321.26	702.53	2304.21	111.4	6.000	6.000	105.4	105.4	0.930	0.930	57.56	57.56	0.975	0.975	56.12	56.12	0.224	1.122
17-Jun	394.86	2415.62	391.86	60.00	60.00	3	3	20.0	20.0	331.86	723.72	2304.26	111.4	6.000	6.000	105.4	105.4	0.930	0.930	57.56	57.56	0.975	0.975	56.12	56.12	0.224	1.122
18-Jun	407.56	2415.67	404.56	60.00	60.00	3	3	20.0	20.0	344.56	749.12	2304.32	111.3	6.000	6.000	105.3	105.3	0.930	0.930	57.55	57.55	0.975	0.975	56.11	56.11	0.224	1.122
19-Jun	423.16	2415.73	420.16	60.00	60.00	3	3	20.0	20.0	360.16	780.32	2304.39	111.3	6.000	6.000	105.3	105.3	0.930	0.930	57.54	57.54	0.975	0.975	56.10	56.10	0.224	1.122
20-Jun	436.37	2415.78	433.37	60.00	60.00	3	3	20.0	20.0	373.37	806.74	2304.45	111.3	6.000	6.000	105.3	105.3	0.930	0.930	57.54	57.54	0.975	0.975	56.10	56.10	0.224	1.122
21-Jun	450.67	2415.83	447.67	60.00	60.00	3	3	20.0	20.0	387.67	835.35	2304.51	111.3	6.000	6.000	105.3	105.3	0.930	0.930	57.53	57.53	0.975	0.975	56.09	56.09	0.224	1.122
22-Jun	473.04	2415.91	470.04	60.00	60.00	3	3	20.0	20.0	410.04	880.09	2304.61	111.3	6.000	6.000	105.3	105.3	0.930	0.930	57.52	57.52	0.975	0.975	56.08	56.08	0.224	1.122
23-Jun	497.41	2415.99	494.41	60.00	60.00	3	3	20.0	20.0	434.41	928.83	2304.71	111.3	6.000	6.000	105.3	105.3	0.930	0.930	57.51	57.51	0.975	0.975	56.08	56.08	0.224	1.122
24-Jun	524.33	2416.08	521.33	60.00	60.00	3	3	20.0	20.0	461.33	982.66	2304.82	111.3	6.000	6.000	105.3	105.3	0.930	0.930	57.51	57.51	0.975	0.975	56.07	56.07	0.224	1.121
25-Jun	544.53	2416.15	541.53	60.00	60.00	3	3	20.0	20.0	481.53	1023.06	2304.89	111.3	6.000	6.000	105.3	105.3	0.930	0.930	57.50	57.50	0.975	0.975	56.06	56.06	0.224	1.121
26-Jun	578.18	2416.25	575.18	60.00	60.00	3	3	20.0	20.0	515.18	1090.35	2305.02	111.2	6.000	6.000	105.2	105.2	0.930	0.930	57.49	57.49	0.975	0.975	56.05	56.05	0.224	1.121
27-Jun	602.59	2416.33	599.59	60.00	60.00	3	3	20.0	20.0	539.59	1139.18	2305.10	111.2	6.000	6.000	105.2	105.2	0.930	0.930	57.48	57.48	0.975	0.975	56.05	56.05	0.224	1.121
28-Jun	623.54	2416.39	620.54	60.00	60.00	3	3	20.0	20.0	560.54	1181.08	2305.17	111.2	6.000	6.000	105.2	105.2	0.930	0.930	57.48	57.48	0.975	0.975	56.04	56.04	0.224	1.121
29-Jun	632.91	2416.42	629.91	60.00	60.00	3	3	20.0	20.0	569.91	1199.82	2305.20	111.2	6.000	6.000	105.2	105.2	0.930	0.930	57.48	57.48	0.975	0.975	56.04	56.04	0.224	1.121
30-Jun	657.89	2416.49	654.89	60.00	60.00	3	3	20.0	20.0	594.89	1249.77	2305.29	111.2	6.000	6.000	105.2	105.2	0.930	0.930	57.47	57.47	0.975	0.975	56.03	56.03	0.224	1.121
01-Jul	660.45	2416.49	657.45	60.00	60.00	3	3	20.0	20.0	597.45	1254.90	2305.29	111.2	6.000	6.000	105.2	105.2	0.930	0.930	57.47	57.47	0.975	0.975	56.03	56.03	0.224	1.121
02-Jul	661.30	2416.50	658.30	60.00	60.00	3	3	20.0	20.0	598.30	1256.60	2305.30	111.2	6.000	6.000	105.2	105.2	0.930	0.930	57.47	57.47	0.975	0.975	56.03	56.03	0.224	1.121
03-Jul	655.99	2416.48	652.99	60.00	60.00	3	3	20.0	20.0	592.99	1245.98	2305.28	111.2	6.000	6.000	105.2	105.2	0.930	0.930	57.47	57.47	0.975	0.975	56.03	56.03	0.224	1.121
04-Jul	654.61	2416.48	651.61	60.00	60.00	3	3	20.0	20.0	591.61	1243.22	2305.28	111.2	6.000	6.000	105.2	105.2	0.930	0.930	57.47	57.47	0.975	0.975	56.03	56.03	0.224	1.121
05-Jul	646.73	2416.46	643.73	60.00	60.00	3	3	20.0	20.0	583.73	1227.47	2305.25	111.2	6.000	6.000	105.2	105.2	0.930	0.930	57.47	57.47	0.975	0.975	56.04	56.04	0.224	1.121
06-Jul	654.97	2416.48	651.97	60.00	60.00	3	3	20.0	20.0	591.97	1243.94	2305.28	111.2	6.000	6.000	105.2	105.2	0.930	0.930	57.47	57.47	0.975	0.975	56.03	56.03	0.224	1.121
07-Jul	659.57	2416.49	656.57	60.00	60.00	3	3	20.0	20.0	596.57	1253.15	2305.29	111.2	6.000	6.000	105.2	105.2	0.930	0.930	57.47	57.47	0.975	0.975	56.03	56.03	0.224	1.121
08-Jul	677.32	2416.54	674.32	60.00	60.00	3	3	20.0	20.0	614.32	1288.65	2305.35	111.2	6.000	6.000	105.2	105.2	0.930	0.930	57.47	57.47	0.975	0.975	56.03	56.03	0.224	1.121
09-Jul	692.59	2416.58	689.59	60.00	60.00	3	3	20.0	20.0	629.59	1319.17	2305.39	111.2	6.000	6.000	105.2	105.2	0.930	0.930	57.46	57.46	0.975	0.975	56.03	56.03	0.224	1.121
10-Jul	702.09	2416.61	699.09	60.00	60.00	3	3	20.0	20.0	639.09	1338.18	2305.42	111.2	6.000	6.000	105.2	105.2	0.930	0.930	57.46	57.46	0.975	0.975	56.02	56.02	0.224	1.120
11-Jul	720.70	2416.65	717.70	60.00	60.00	3	3	20.0	20.0	657.70	1375.40	2305.48	111.2	6.000	6.000	105.2	105.2	0.930	0.930	57.46	57.46	0.975	0.975	56.02	56.02	0.224	1.120
12-Jul	742.10	2416.71	739.10	60.00	60.00	3	3	20.0	20.0	679.10	1418.19	2305.54	111.2	6.000	6.000	105.2	105.2	0.930	0.930	57.45	57.45	0.975	0.975	56.02	56.02	0.224	1.120

Day	River Flows at Weir (cumecs)	Head Water Level (m)	Flows less Ecological Flows (cumecs)	Plant Peak Discharge (cumecs)	Plant Off-Peak Discharge (cumecs)	No. of Turbines in Operation for Peaking	No. of Turbines in Operation for Off-Peaking	Discharge Per Turbine of Peaking Plant (cumecs)	Discharge Per Turbine of Peaking Plant (cumecs)	Spilled Discharge (cumecs)	Hunza River Flows at PH (cumecs)	TWL (masl)	Gross Head (m)	Head Loss Peaking Plant (m)	Head Loss Off-Peaking Plant (m)	Net Head Peaking Plant (m)	Net Head Off-Peaking Plant (m)	Turb Eff. For Peaking Turbines	Turb Eff. For Peaking Turbines	Peaking Turbines Output (MW)	Off-Peaking Turbines Output (MW)	Peaking Generator Efficiency	Off-Peaking Generator Efficiency	Peaking Generators Output (MW)	Off-Peaking Generators Output (MW)	Peaking Plant Energy at Generator Terminal (GWh)	Off-Peaking Plant Energy at Generator Terminal (GWh)
13-Jul	770.25	2416.77	767.25	60.00	60.00	3	3	20.0	20.0	707.25	1474.50	2305.61	111.2	6.000	6.000	105.2	105.2	0.930	0.930	57.45	57.45	0.975	0.975	56.01	56.01	0.224	1.120
14-Jul	785.54	2416.81	782.54	60.00	60.00	3	3	20.0	20.0	722.54	1505.08	2305.65	111.2	6.000	6.000	105.2	105.2	0.930	0.930	57.44	57.44	0.975	0.975	56.01	56.01	0.224	1.120
15-Jul	784.33	2416.81	781.33	60.00	60.00	3	3	20.0	20.0	721.33	1502.66	2305.65	111.2	6.000	6.000	105.2	105.2	0.930	0.930	57.44	57.44	0.975	0.975	56.01	56.01	0.224	1.120
16-Jul	789.25	2416.82	786.25	60.00	60.00	3	3	20.0	20.0	726.25	1512.50	2305.66	111.2	6.000	6.000	105.2	105.2	0.930	0.930	57.44	57.44	0.975	0.975	56.01	56.01	0.224	1.120
17-Jul	780.04	2416.80	777.04	60.00	60.00	3	3	20.0	20.0	717.04	1494.09	2305.64	111.2	6.000	6.000	105.2	105.2	0.930	0.930	57.45	57.45	0.975	0.975	56.01	56.01	0.224	1.120
18-Jul	769.65	2416.77	766.65	60.00	60.00	3	3	20.0	20.0	706.65	1473.31	2305.61	111.2	6.000	6.000	105.2	105.2	0.930	0.930	57.45	57.45	0.975	0.975	56.01	56.01	0.224	1.120
19-Jul	766.45	2416.76	763.45	60.00	60.00	3	3	20.0	20.0	703.45	1466.91	2305.60	111.2	6.000	6.000	105.2	105.2	0.930	0.930	57.45	57.45	0.975	0.975	56.01	56.01	0.224	1.120
20-Jul	778.75	2416.79	775.75	60.00	60.00	3	3	20.0	20.0	715.75	1491.51	2305.64	111.2	6.000	6.000	105.2	105.2	0.930	0.930	57.45	57.45	0.975	0.975	56.01	56.01	0.224	1.120
21-Jul	797.94	2416.84	794.94	60.00	60.00	3	3	20.0	20.0	734.94	1529.88	2305.69	111.1	6.000	6.000	105.1	105.1	0.930	0.930	57.44	57.44	0.975	0.975	56.00	56.00	0.224	1.120
22-Jul	804.41	2416.85	801.41	60.00	60.00	3	3	20.0	20.0	741.41	1542.83	2305.70	111.1	6.000	6.000	105.1	105.1	0.930	0.930	57.44	57.44	0.975	0.975	56.00	56.00	0.224	1.120
23-Jul	802.78	2416.85	799.78	60.00	60.00	3	3	20.0	20.0	739.78	1539.56	2305.70	111.1	6.000	6.000	105.1	105.1	0.930	0.930	57.44	57.44	0.975	0.975	56.00	56.00	0.224	1.120
24-Jul	783.86	2416.80	780.86	60.00	60.00	3	3	20.0	20.0	720.86	1501.72	2305.65	111.2	6.000	6.000	105.2	105.2	0.930	0.930	57.44	57.44	0.975	0.975	56.01	56.01	0.224	1.120
25-Jul	774.21	2416.78	771.21	60.00	60.00	3	3	20.0	20.0	711.21	1482.43	2305.62	111.2	6.000	6.000	105.2	105.2	0.930	0.930	57.45	57.45	0.975	0.975	56.01	56.01	0.224	1.120
26-Jul	756.13	2416.74	753.13	60.00	60.00	3	3	20.0	20.0	693.13	1446.25	2305.58	111.2	6.000	6.000	105.2	105.2	0.930	0.930	57.45	57.45	0.975	0.975	56.01	56.01	0.224	1.120
27-Jul	746.31	2416.72	743.31	60.00	60.00	3	3	20.0	20.0	683.31	1426.61	2305.55	111.2	6.000	6.000	105.2	105.2	0.930	0.930	57.45	57.45	0.975	0.975	56.02	56.02	0.224	1.120
28-Jul	776.14	2416.79	773.14	60.00	60.00	3	3	20.0	20.0	713.14	1486.29	2305.63	111.2	6.000	6.000	105.2	105.2	0.930	0.930	57.45	57.45	0.975	0.975	56.01	56.01	0.224	1.120
29-Jul	790.43	2416.82	787.43	60.00	60.00	3	3	20.0	20.0	727.43	1514.86	2305.67	111.2	6.000	6.000	105.2	105.2	0.930	0.930	57.44	57.44	0.975	0.975	56.01	56.01	0.224	1.120
30-Jul	802.87	2416.85	799.87	60.00	60.00	3	3	20.0	20.0	739.87	1539.74	2305.70	111.1	6.000	6.000	105.1	105.1	0.930	0.930	57.44	57.44	0.975	0.975	56.00	56.00	0.224	1.120
31-Jul	808.63	2416.86	805.63	60.00	60.00	3	3	20.0	20.0	745.63	1551.26	2305.72	111.1	6.000	6.000	105.1	105.1	0.930	0.930	57.44	57.44	0.975	0.975	56.00	56.00	0.224	1.120
01-Aug	802.45	2416.85	799.45	60.00	60.00	3	3	20.0	20.0	739.45	1538.91	2305.70	111.1	6.000	6.000	105.1	105.1	0.930	0.930	57.44	57.44	0.975	0.975	56.00	56.00	0.224	1.120
02-Aug	811.70	2416.87	808.70	60.00	60.00	3	3	20.0	20.0	748.70	1557.41	2305.72	111.1	6.000	6.000	105.1	105.1	0.930	0.930	57.44	57.44	0.975	0.975	56.00	56.00	0.224	1.120
03-Aug	828.50	2416.90	825.50	60.00	60.00	3	3	20.0	20.0	765.50	1591.00	2305.77	111.1	6.000	6.000	105.1	105.1	0.930	0.930	57.43	57.43	0.975	0.975	56.00	56.00	0.224	1.120
04-Aug	846.97	2416.94	843.97	60.00	60.00	3	3	20.0	20.0	783.97	1627.94	2305.81	111.1	6.000	6.000	105.1	105.1	0.930	0.930	57.43	57.43	0.975	0.975	55.99	55.99	0.224	1.120
05-Aug	845.96	2416.94	842.96	60.00	60.00	3	3	20.0	20.0	782.96	1625.92	2305.81	111.1	6.000	6.000	105.1	105.1	0.930	0.930	57.43	57.43	0.975	0.975	55.99	55.99	0.224	1.120
06-Aug	842.46	2416.93	839.46	60.00	60.00	3	3	20.0	20.0	779.46	1618.92	2305.80	111.1	6.000	6.000	105.1	105.1	0.930	0.930	57.43	57.43	0.975	0.975	55.99	55.99	0.224	1.120
07-Aug	847.37	2416.94	844.37	60.00	60.00	3	3	20.0	20.0	784.37	1628.73	2305.81	111.1	6.000	6.000	105.1	105.1	0.930	0.930	57.43	57.43	0.975	0.975	55.99	55.99	0.224	1.120
08-Aug	849.86	2416.94	846.86	60.00	60.00	3	3	20.0	20.0	786.86	1633.71	2305.82	111.1	6.000	6.000	105.1	105.1	0.930	0.930	57.43	57.43	0.975	0.975	55.99	55.99	0.224	1.120
09-Aug	834.10	2416.91	831.10	60.00	60.00	3	3	20.0	20.0	771.10	1602.20	2305.78	111.1	6.000	6.000	105.1	105.1	0.930	0.930	57.43	57.43	0.975	0.975	56.00	56.00	0.224	1.120
10-Aug	801.56	2416.84	798.56	60.00	60.00	3	3	20.0	20.0	738.56	1537.13	2305.70	111.1	6.000	6.000	105.1	105.1	0.930	0.930	57.44	57.44	0.975	0.975	56.00	56.00	0.224	1.120
11-Aug	776.38	2416.79	773.38	60.00	60.00	3	3	20.0	20.0	713.38	1486.77	2305.63	111.2	6.000	6.000	105.2	105.2	0.930	0.930	57.45	57.45	0.975	0.975	56.01	56.01	0.224	1.120
12-Aug	764.57	2416.76	761.57	60.00	60.00	3	3	20.0	20.0	701.57	1463.14	2305.60	111.2	6.000	6.000	105.2	105.2	0.930	0.930	57.45	57.45	0.975	0.975	56.01	56.01	0.224	1.120
13-Aug	750.55	2416.73	747.55	60.00	60.00	3	3	20.0	20.0	687.55	1435.10	2305.56	111.2	6.000	6.000	105.2	105.2	0.930	0.930	57.45	57.45	0.975	0.975	56.01	56.01	0.224	1.120
14-Aug	739.47	2416.70	736.47	60.00	60.00	3	3	20.0	20.0	676.47	1412.93	2305.53	111.2	6.000	6.000	105.2	105.2	0.930	0.930	57.45	57.45	0.975	0.975	56.02	56.02	0.224	1.120
15-Aug	723.97	2416.66	720.97	60.00	60.00	3	3	20.0	20.0	660.97	1381.95	2305.48	111.2	6.000	6.000	105.2	105.2	0.930	0.930	57.46	57.46	0.975	0.975	56.02	56.02	0.224	1.120
16-Aug	717.83	2416.65	714.83	60.00	60.00	3	3	20.0	20.0	654.83	1369.65	2305.47	111.2	6.000	6.000	105.2	105.2	0.930	0.930	57.46	57.46	0.975	0.975	56.02	56.02	0.224	1.120
17-Aug	709.87	2416.63	706.87	60.00	60.00	3	3	20.0	20.0	646.87	1353.75	2305.44	111.2	6.000	6.000	105.2	105.2	0.930	0.930	57.46	57.46	0.975	0.975	56.02	56.02	0.224	1.120
18-Aug	706.82	2416.62	703.82	60.00	60.00	3	3	20.0	20.0	643.82	1347.65	2305.43	111.2	6.000	6.000	105.2	105.2	0.930	0.930	57.46	57.46	0.975	0.975	56.02	56.02	0.224	1.120
19-Aug	694.53	2416.59	691.53	60.00	60.00	3	3	20.0	20.0	631.53	1323.06	2305.40	111.2	6.000	6.000	105.2	105.2	0.930	0.930	57.46	57.46	0.975	0.975	56.03	56.03	0.224	1.121
20-Aug	693.48	2416.58	690.48	60.00	60.00	3	3	20.0	20.0	630.48	1320.95	2305.40	111.2	6.000	6.000	105.2	105.2	0.930	0.930	57.46	57.46	0.975	0.975	56.03	56.03	0.224	1.121

Day	River Flows at Weir (cumecs)	Head Water Level (m)	Flows less Ecological Flows (cumecs)	Plant Peak Discharge (cumecs)	Plant Off-Peak Discharge (cumecs)	No. of Turbines in Operation for Peaking	No. of Turbines in Operation for Off-Peaking	Discharge Per Turbine of Peaking Plant (cumecs)	Discharge Per Turbine of Peaking Plant (cumecs)	Spilled Discharge (cumecs)	Hunza River Flows at PH (cumecs)	TWL (masl)	Gross Head (m)	Head Loss Peaking Plant (m)	Head Loss Off-Peaking Plant (m)	Net Head Peaking Plant (m)	Net Head Off-Peaking Plant (m)	Turb Eff. For Peaking Turbines	Turb Eff. For Peaking Turbines	Peaking Turbines Output (MW)	Off-Peaking Turbines Output (MW)	Peaking Generator Efficiency	Off-Peaking Generator Efficiency	Peaking Generators Output (MW)	Off-Peaking Generators Output (MW)	Peaking Plant Energy at Generator Terminal (GWh)	Off-Peaking Plant Energy at Generator Terminal (GWh)
21-Aug	676.34	2416.54	673.34	60.00	60.00	3	3	20.0	20.0	613.34	1286.68	2305.34	111.2	6.000	6.000	105.2	105.2	0.930	0.930	57.47	57.47	0.975	0.975	56.03	56.03	0.224	1.121
22-Aug	643.71	2416.45	640.71	60.00	60.00	3	3	20.0	20.0	580.71	1221.42	2305.24	111.2	6.000	6.000	105.2	105.2	0.930	0.930	57.47	57.47	0.975	0.975	56.04	56.04	0.224	1.121
23-Aug	618.04	2416.37	615.04	60.00	60.00	3	3	20.0	20.0	555.04	1170.08	2305.16	111.2	6.000	6.000	105.2	105.2	0.930	0.930	57.48	57.48	0.975	0.975	56.04	56.04	0.224	1.121
24-Aug	600.94	2416.32	597.94	60.00	60.00	3	3	20.0	20.0	537.94	1135.87	2305.10	111.2	6.000	6.000	105.2	105.2	0.930	0.930	57.48	57.48	0.975	0.975	56.05	56.05	0.224	1.121
25-Aug	598.01	2416.31	595.01	60.00	60.00	3	3	20.0	20.0	535.01	1130.03	2305.09	111.2	6.000	6.000	105.2	105.2	0.930	0.930	57.48	57.48	0.975	0.975	56.05	56.05	0.224	1.121
26-Aug	579.70	2416.26	576.70	60.00	60.00	3	3	20.0	20.0	516.70	1093.39	2305.02	111.2	6.000	6.000	105.2	105.2	0.930	0.930	57.49	57.49	0.975	0.975	56.05	56.05	0.224	1.121
27-Aug	562.07	2416.20	559.07	60.00	60.00	3	3	20.0	20.0	499.07	1058.14	2304.96	111.2	6.000	6.000	105.2	105.2	0.930	0.930	57.49	57.49	0.975	0.975	56.06	56.06	0.224	1.121
28-Aug	540.16	2416.13	537.16	60.00	60.00	3	3	20.0	20.0	477.16	1014.32	2304.88	111.3	6.000	6.000	105.3	105.3	0.930	0.930	57.50	57.50	0.975	0.975	56.06	56.06	0.224	1.121
29-Aug	532.33	2416.11	529.33	60.00	60.00	3	3	20.0	20.0	469.33	998.66	2304.85	111.3	6.000	6.000	105.3	105.3	0.930	0.930	57.50	57.50	0.975	0.975	56.06	56.06	0.224	1.121
30-Aug	528.74	2416.10	525.74	60.00	60.00	3	3	20.0	20.0	465.74	991.49	2304.83	111.3	6.000	6.000	105.3	105.3	0.930	0.930	57.50	57.50	0.975	0.975	56.07	56.07	0.224	1.121
31-Aug	519.88	2416.07	516.88	60.00	60.00	3	3	20.0	20.0	456.88	973.76	2304.80	111.3	6.000	6.000	105.3	105.3	0.930	0.930	57.51	57.51	0.975	0.975	56.07	56.07	0.224	1.121
01-Sep	497.53	2415.99	494.53	60.00	60.00	3	3	20.0	20.0	434.53	929.06	2304.71	111.3	6.000	6.000	105.3	105.3	0.930	0.930	57.51	57.51	0.975	0.975	56.08	56.08	0.224	1.122
02-Sep	479.19	2415.93	476.19	60.00	60.00	3	3	20.0	20.0	416.19	892.37	2304.64	111.3	6.000	6.000	105.3	105.3	0.930	0.930	57.52	57.52	0.975	0.975	56.08	56.08	0.224	1.122
03-Sep	473.67	2415.91	470.67	60.00	60.00	3	3	20.0	20.0	410.67	881.35	2304.61	111.3	6.000	6.000	105.3	105.3	0.930	0.930	57.52	57.52	0.975	0.975	56.08	56.08	0.224	1.122
04-Sep	465.79	2415.88	462.79	60.00	60.00	3	3	20.0	20.0	402.79	865.58	2304.58	111.3	6.000	6.000	105.3	105.3	0.930	0.930	57.53	57.53	0.975	0.975	56.09	56.09	0.224	1.122
05-Sep	448.80	2415.82	445.80	60.00	60.00	3	3	20.0	20.0	385.80	831.60	2304.51	111.3	6.000	6.000	105.3	105.3	0.930	0.930	57.53	57.53	0.975	0.975	56.09	56.09	0.224	1.122
06-Sep	428.23	2415.75	425.23	60.00	60.00	3	3	20.0	20.0	365.23	790.47	2304.41	111.3	6.000	6.000	105.3	105.3	0.930	0.930	57.54	57.54	0.975	0.975	56.10	56.10	0.224	1.122
07-Sep	415.61	2415.70	412.61	60.00	60.00	3	3	20.0	20.0	352.61	765.22	2304.36	111.3	6.000	6.000	105.3	105.3	0.930	0.930	57.55	57.55	0.975	0.975	56.11	56.11	0.224	1.122
08-Sep	404.69	2415.66	401.69	60.00	60.00	3	3	20.0	20.0	341.69	743.38	2304.31	111.4	6.000	6.000	105.4	105.4	0.930	0.930	57.55	57.55	0.975	0.975	56.11	56.11	0.224	1.122
09-Sep	390.08	2415.60	387.08	60.00	60.00	3	3	20.0	20.0	327.08	714.16	2304.24	111.4	6.000	6.000	105.4	105.4	0.930	0.930	57.56	57.56	0.975	0.975	56.12	56.12	0.224	1.122
10-Sep	380.13	2415.56	377.13	60.00	60.00	3	3	20.0	20.0	317.13	694.27	2304.19	111.4	6.000	6.000	105.4	105.4	0.930	0.930	57.56	57.56	0.975	0.975	56.12	56.12	0.224	1.122
11-Sep	369.24	2415.52	366.24	60.00	60.00	3	3	20.0	20.0	306.24	672.48	2304.14	111.4	6.000	6.000	105.4	105.4	0.930	0.930	57.57	57.57	0.975	0.975	56.13	56.13	0.225	1.123
12-Sep	361.17	2415.49	358.17	60.00	60.00	3	3	20.0	20.0	298.17	656.34	2304.10	111.4	6.000	6.000	105.4	105.4	0.930	0.930	57.57	57.57	0.975	0.975	56.14	56.14	0.225	1.123
13-Sep	353.60	2415.46	350.60	60.00	60.00	3	3	20.0	20.0	290.60	641.19	2304.06	111.4	6.000	6.000	105.4	105.4	0.930	0.930	57.58	57.58	0.975	0.975	56.14	56.14	0.225	1.123
14-Sep	340.02	2415.40	337.02	60.00	60.00	3	3	20.0	20.0	277.02	614.05	2303.99	111.4	6.000	6.000	105.4	105.4	0.930	0.930	57.59	57.59	0.975	0.975	56.15	56.15	0.225	1.123
15-Sep	327.78	2415.36	324.78	60.00	60.00	3	3	20.0	20.0	264.78	589.56	2303.93	111.4	6.000	6.000	105.4	105.4	0.930	0.930	57.59	57.59	0.975	0.975	56.15	56.15	0.225	1.123
16-Sep	313.17	2415.29	310.17	60.00	60.00	3	3	20.0	20.0	250.17	560.33	2303.85	111.4	6.000	6.000	105.4	105.4	0.930	0.930	57.60	57.60	0.975	0.975	56.16	56.16	0.225	1.123
17-Sep	299.12	2415.24	296.12	60.00	60.00	3	3	20.0	20.0	236.12	532.23	2303.77	111.5	6.000	6.000	105.5	105.5	0.930	0.930	57.61	57.61	0.975	0.975	56.17	56.17	0.225	1.123
18-Sep	282.21	2415.16	279.21	60.00	60.00	3	3	20.0	20.0	219.21	498.43	2303.68	111.5	6.000	6.000	105.5	105.5	0.930	0.930	57.63	57.63	0.975	0.975	56.18	56.18	0.225	1.124
19-Sep	269.78	2415.11	266.78	60.00	60.00	3	3	20.0	20.0	206.78	473.56	2303.61	111.5	6.000	6.000	105.5	105.5	0.930	0.930	57.63	57.63	0.975	0.975	56.19	56.19	0.225	1.124
20-Sep	261.51	2415.08	258.51	60.00	60.00	3	3	20.0	20.0	198.51	457.02	2303.56	111.5	6.000	6.000	105.5	105.5	0.930	0.930	57.64	57.64	0.975	0.975	56.20	56.20	0.225	1.124
21-Sep	248.62	2415.02	245.62	60.00	60.00	3	3	20.0	20.0	185.62	431.25	2303.49	111.5	6.000	6.000	105.5	105.5	0.930	0.930	57.65	57.65	0.975	0.975	56.21	56.21	0.225	1.124
22-Sep	235.32	2414.96	232.32	60.00	60.00	3	3	20.0	20.0	172.32	404.64	2303.41	111.6	6.000	6.000	105.6	105.6	0.930	0.930	57.66	57.66	0.975	0.975	56.22	56.22	0.225	1.124
23-Sep	225.05	2414.91	222.05	60.00	60.00	3	3	20.0	20.0	162.05	384.11	2303.35	111.6	6.000	6.000	105.6	105.6	0.930	0.930	57.67	57.67	0.975	0.975	56.23	56.23	0.225	1.125
24-Sep	216.61	2414.88	213.61	60.00	60.00	3	3	20.0	20.0	153.61	367.23	2303.29	111.6	6.000	6.000	105.6	105.6	0.930	0.930	57.68	57.68	0.975	0.975	56.24	56.24	0.225	1.125
25-Sep	206.93	2414.83	203.93	60.00	60.00	3	3	20.0	20.0	143.93	347.87	2303.23	111.6	6.000	6.000	105.6	105.6	0.930	0.930	57.69	57.69	0.975	0.975	56.25	56.25	0.225	1.125
26-Sep	196.79	2414.79	193.79	60.00	60.00	3	3	20.0	20.0	133.79	327.57	2303.17	111.6	6.000	6.000	105.6	105.6	0.930	0.930	57.70	57.70	0.975	0.975	56.25	56.25	0.225	1.125
27-Sep	189.26	2414.75	186.26	60.00	60.00	3	3	20.0	20.0	126.26	312.53	2303.12	111.6	6.000	6.000	105.6	105.6	0.930	0.930	57.70	57.70	0.975	0.975	56.26	56.26	0.225	1.125
28-Sep	181.50	2414.71	178.50	60.00	60.00	3	3	20.0	20.0	118.50	296.99	2303.07	111.6	6.000	6.000	105.6	105.6	0.930	0.930	57.71	57.71	0.975	0.975	56.27	56.27	0.225	1.125

Day	River Flows at Weir (cumecs)	Head Water Level (m)	Flows less Ecological Flows (cumecs)	Plant Peak Discharge (cumecs)	Plant Off-Peak Discharge (cumecs)	No. of Turbines in Operation for Peaking	No. of Turbines in Operation for Off-Peaking	Discharge Per Turbine of Peaking Plant (cumecs)	Discharge Per Turbine of Peaking Plant (cumecs)	Spilled Discharge (cumecs)	Hunza River Flows at PH (cumecs)	TWL (masl)	Gross Head (m)	Head Loss Peaking Plant (m)	Head Loss Off-Peaking Plant (m)	Net Head Peaking Plant (m)	Net Head Off-Peaking Plant (m)	Turb Eff. For Peaking Turbines	Turb Eff. For Peaking Turbines	Peaking Turbines Output (MW)	Off-Peaking Turbines Output (MW)	Peaking Generator Efficiency	Off-Peaking Generator Efficiency	Peaking Generators Output (MW)	Off-Peaking Generators Output (MW)	Peaking Plant Energy at Generator Terminal (GWh)	Off-Peaking Plant Energy at Generator Terminal (GWh)
29-Sep	174.93	2414.68	171.93	60.00	60.00	3	3	20.0	20.0	111.93	283.86	2303.03	111.7	6.000	6.000	105.7	105.7	0.930	0.930	57.72	57.72	0.975	0.975	56.28	56.28	0.225	1.126
30-Sep	169.48	2414.66	166.48	60.00	60.00	3	3	20.0	20.0	106.48	272.96	2302.99	111.7	6.000	6.000	105.7	105.7	0.930	0.930	57.72	57.72	0.975	0.975	56.28	56.28	0.225	1.126
01-Oct	163.54	2414.63	160.54	60.00	60.00	3	3	20.0	20.0	100.54	261.07	2302.95	111.7	6.000	6.000	105.7	105.7	0.930	0.930	57.73	57.73	0.975	0.975	56.29	56.29	0.225	1.126
02-Oct	157.52	2414.60	154.52	60.00	60.00	3	3	20.0	20.0	94.52	249.04	2302.91	111.7	6.000	6.000	105.7	105.7	0.930	0.930	57.74	57.74	0.975	0.975	56.29	56.29	0.225	1.126
03-Oct	152.27	2414.58	149.27	60.00	60.00	3	3	20.0	20.0	89.27	238.54	2302.88	111.7	6.000	6.000	105.7	105.7	0.930	0.930	57.74	57.74	0.975	0.975	56.30	56.30	0.225	1.126
04-Oct	146.89	2414.55	143.89	60.00	60.00	3	3	20.0	20.0	83.89	227.77	2302.84	111.7	6.000	6.000	105.7	105.7	0.930	0.930	57.75	57.75	0.975	0.975	56.30	56.30	0.225	1.126
05-Oct	141.89	2414.53	138.89	60.00	60.00	3	3	20.0	20.0	78.89	217.78	2302.81	111.7	6.000	6.000	105.7	105.7	0.930	0.930	57.75	57.75	0.975	0.975	56.31	56.31	0.225	1.126
06-Oct	137.84	2414.51	134.84	60.00	60.00	3	3	20.0	20.0	74.84	209.68	2302.78	111.7	6.000	6.000	105.7	105.7	0.930	0.930	57.76	57.76	0.975	0.975	56.31	56.31	0.225	1.126
07-Oct	132.51	2414.48	129.51	60.00	60.00	3	3	20.0	20.0	69.51	199.02	2302.74	111.7	6.000	6.000	105.7	105.7	0.930	0.930	57.76	57.76	0.975	0.975	56.32	56.32	0.225	1.126
08-Oct	127.83	2414.46	124.83	60.00	60.00	3	3	20.0	20.0	64.83	189.66	2302.71	111.7	6.000	6.000	105.7	105.7	0.930	0.930	57.77	57.77	0.975	0.975	56.33	56.33	0.225	1.127
09-Oct	123.23	2414.44	120.23	60.00	60.00	3	3	20.0	20.0	60.23	180.46	2302.68	111.8	6.000	6.000	105.8	105.8	0.930	0.930	57.77	57.77	0.975	0.975	56.33	56.33	0.225	1.127
10-Oct	118.75	2414.41	115.75	60.00	60.00	3	3	20.0	20.0	55.75	171.51	2302.65	111.8	6.000	6.000	105.8	105.8	0.930	0.930	57.78	57.78	0.975	0.975	56.34	56.34	0.225	1.127
11-Oct	115.50	2414.40	112.50	60.00	60.00	3	3	20.0	20.0	52.50	164.99	2302.62	111.8	6.000	6.000	105.8	105.8	0.930	0.930	57.78	57.78	0.975	0.975	56.34	56.34	0.225	1.127
12-Oct	111.50	2414.38	108.50	60.00	60.00	3	3	20.0	20.0	48.50	157.00	2302.59	111.8	6.000	6.000	105.8	105.8	0.930	0.930	57.79	57.79	0.975	0.975	56.34	56.34	0.225	1.127
13-Oct	108.09	2414.36	105.09	60.00	60.00	3	3	20.0	20.0	45.09	150.17	2302.57	111.8	6.000	6.000	105.8	105.8	0.930	0.930	57.79	57.79	0.975	0.975	56.35	56.35	0.225	1.127
14-Oct	104.39	2414.34	101.39	60.00	60.00	3	3	20.0	20.0	41.39	142.78	2302.54	111.8	6.000	6.000	105.8	105.8	0.930	0.930	57.80	57.80	0.975	0.975	56.35	56.35	0.225	1.127
15-Oct	101.55	2414.33	98.55	60.00	60.00	3	3	20.0	20.0	38.55	137.10	2302.52	111.8	6.000	6.000	105.8	105.8	0.930	0.930	57.80	57.80	0.975	0.975	56.36	56.36	0.225	1.127
16-Oct	98.45	2414.31	95.45	60.00	60.00	3	3	20.0	20.0	35.45	130.89	2302.50	111.8	6.000	6.000	105.8	105.8	0.930	0.930	57.80	57.80	0.975	0.975	56.36	56.36	0.225	1.127
17-Oct	95.07	2414.30	92.07	60.00	60.00	3	3	20.0	20.0	32.07	124.14	2302.47	111.8	6.000	6.000	105.8	105.8	0.930	0.930	57.81	57.81	0.975	0.975	56.36	56.36	0.225	1.127
18-Oct	92.62	2414.28	89.62	60.00	60.00	3	3	20.0	20.0	29.62	119.23	2302.46	111.8	6.000	6.000	105.8	105.8	0.930	0.930	57.81	57.81	0.975	0.975	56.37	56.37	0.225	1.127
19-Oct	89.95	2414.27	86.95	60.00	60.00	3	3	20.0	20.0	26.95	113.90	2302.44	111.8	6.000	6.000	105.8	105.8	0.930	0.930	57.82	57.82	0.975	0.975	56.37	56.37	0.225	1.127
20-Oct	88.06	2414.26	85.06	60.00	60.00	3	3	20.0	20.0	25.06	110.11	2302.42	111.8	6.000	6.000	105.8	105.8	0.930	0.930	57.82	57.82	0.975	0.975	56.37	56.37	0.225	1.127
21-Oct	85.42	2414.25	82.42	60.00	60.00	3	3	20.0	20.0	22.42	104.83	2302.40	111.8	6.000	6.000	105.8	105.8	0.930	0.930	57.82	57.82	0.975	0.975	56.38	56.38	0.226	1.128
22-Oct	82.99	2414.23	79.99	60.00	60.00	3	3	20.0	20.0	19.99	99.99	2302.39	111.8	6.000	6.000	105.8	105.8	0.930	0.930	57.82	57.82	0.975	0.975	56.38	56.38	0.226	1.128
23-Oct	80.99	2414.22	77.99	60.00	60.00	3	3	20.0	20.0	17.99	95.97	2302.37	111.9	6.000	6.000	105.9	105.9	0.930	0.930	57.83	57.83	0.975	0.975	56.38	56.38	0.226	1.128
24-Oct	79.17	2414.21	76.17	60.00	60.00	3	3	20.0	20.0	16.17	92.33	2302.36	111.9	6.000	6.000	105.9	105.9	0.930	0.930	57.83	57.83	0.975	0.975	56.38	56.38	0.226	1.128
25-Oct	77.26	2414.21	74.26	60.00	60.00	3	3	20.0	20.0	14.26	88.52	2302.34	111.9	6.000	6.000	105.9	105.9	0.930	0.930	57.83	57.83	0.975	0.975	56.39	56.39	0.226	1.128
26-Oct	75.66	2414.20	72.66	60.00	60.00	3	3	20.0	20.0	12.66	85.32	2302.33	111.9	6.000	6.000	105.9	105.9	0.930	0.930	57.83	57.83	0.975	0.975	56.39	56.39	0.226	1.128
27-Oct	73.66	2414.19	70.66	60.00	60.00	3	3	20.0	20.0	10.66	81.33	2302.32	111.9	6.000	6.000	105.9	105.9	0.930	0.930	57.84	57.84	0.975	0.975	56.39	56.39	0.226	1.128
28-Oct	72.72	2414.18	69.72	60.00	60.00	3	3	20.0	20.0	9.72	79.44	2302.31	111.9	6.000	6.000	105.9	105.9	0.930	0.930	57.84	57.84	0.975	0.975	56.39	56.39	0.226	1.128
29-Oct	71.30	2414.17	68.30	60.00	60.00	3	3	20.0	20.0	8.30	76.61	2302.30	111.9	6.000	6.000	105.9	105.9	0.930	0.930	57.84	57.84	0.975	0.975	56.39	56.39	0.226	1.128
30-Oct	70.05	2414.17	67.05	60.00	60.00	3	3	20.0	20.0	7.05	74.10	2302.29	111.9	6.000	6.000	105.9	105.9	0.930	0.930	57.84	57.84	0.975	0.975	56.40	56.40	0.226	1.128
31-Oct	68.76	2414.16	65.76	60.00	60.00	3	3	20.0	20.0	5.76	71.53	2302.28	111.9	6.000	6.000	105.9	105.9	0.930	0.930	57.84	57.84	0.975	0.975	56.40	56.40	0.226	1.128
01-Nov	67.37	2414.15	64.37	60.00	60.00	3	3	20.0	20.0	4.37	68.75	2302.27	111.9	6.000	6.000	105.9	105.9	0.930	0.930	57.85	57.85	0.975	0.975	56.40	56.40	0.226	1.128
02-Nov	66.40	2414.15	63.40	60.00	60.00	3	3	20.0	20.0	3.40	66.81	2302.26	111.9	6.000	6.000	105.9	105.9	0.930	0.930	57.85	57.85	0.975	0.975	56.40	56.40	0.226	1.128
03-Nov	65.82	2414.15	62.82	60.00	60.00	3	3	20.0	20.0	2.82	65.64	2302.26	111.9	6.000	6.000	105.9	105.9	0.930	0.930	57.85	57.85	0.975	0.975	56.40	56.40	0.226	1.128
04-Nov	64.61	2414.14	61.61	60.00	60.00	3	3	20.0	20.0	1.61	63.22	2302.25	111.9	6.000	6.000	105.9	105.9	0.930	0.930	57.85	57.85	0.975	0.975	56.40	56.40	0.226	1.128
05-Nov	63.35	2414.13	60.35	60.00	60.00	3	3	20.0	20.0	0.35	60.70	2302.24	111.9	6.000	6.000	105.9	105.9	0.930	0.930	57.85	57.85	0.975	0.975	56.40	56.40	0.226	1.128
06-Nov	62.30	2414.13	59.30	60.00	49.30	3	3	20.0	16.4	0.00	59.30	2302.23	111.9	6.000	4.051	105.9	107.8	0.930	0.918	57.85	47.80	0.975	0.974	56.40	46.55	0.226	0.931

Day	River Flows at Weir (cumecs)	Head Water Level (m)	Flows less Ecological Flows (cumecs)	Plant Peak Discharge (cumecs)	Plant Off-Peak Discharge (cumecs)	No. of Turbines in Operation for Peaking	No. of Turbines in Operation for Off-Peaking	Discharge Per Turbine of Peaking Plant (cumecs)	Discharge Per Turbine of Peaking Plant (cumecs)	Spilled Discharge (cumecs)	Hunza River Flows at PH (cumecs)	TWL (masl)	Gross Head (m)	Head Loss Peaking Plant (m)	Head Loss Off-Peaking Plant (m)	Net Head Peaking Plant (m)	Net Head Off-Peaking Plant (m)	Turb Eff. For Peaking Turbines	Turb Eff. For Peaking Turbines	Peaking Turbines Output (MW)	Off-Peaking Turbines Output (MW)	Peaking Generator Efficiency	Off-Peaking Generator Efficiency	Peaking Generators Output (MW)	Off-Peaking Generators Output (MW)	Peaking Plant Energy at Generator Terminal (GWh)	Off-Peaking Plant Energy at Generator Terminal (GWh)
07-Nov	61.45	2414.12	58.45	60.00	48.45	3	3	20.0	16.2	0.00	58.45	2302.23	111.9	6.000	3.913	105.9	108.0	0.930	0.917	57.85	46.95	0.975	0.974	56.40	45.72	0.226	0.914
08-Nov	60.40	2414.12	57.40	60.00	47.40	3	3	20.0	15.8	0.00	57.40	2302.22	111.9	6.000	3.744	105.9	108.1	0.930	0.913	57.85	45.84	0.975	0.973	56.40	44.63	0.226	0.893
09-Nov	59.65	2414.11	56.65	60.00	46.65	3	3	20.0	15.6	0.00	56.65	2302.22	111.9	6.000	3.627	105.9	108.3	0.930	0.911	57.85	45.03	0.975	0.973	56.40	43.82	0.226	0.876
10-Nov	58.64	2414.11	55.64	60.00	45.64	3	3	20.0	15.2	0.00	55.64	2302.22	111.9	6.000	3.471	105.9	108.4	0.930	0.907	57.85	43.92	0.975	0.973	56.40	42.72	0.226	0.854
11-Nov	57.70	2414.10	54.70	60.00	44.70	3	3	20.0	14.9	0.00	54.70	2302.21	111.9	6.000	3.330	105.9	108.6	0.930	0.903	57.85	42.90	0.975	0.972	56.40	41.71	0.226	0.834
12-Nov	56.82	2414.10	53.82	60.00	43.82	3	3	20.0	14.6	0.00	53.82	2302.21	111.9	6.000	3.201	105.9	108.7	0.930	0.900	57.85	41.95	0.975	0.972	56.40	40.78	0.226	0.816
13-Nov	56.23	2414.10	53.23	60.00	43.23	3	3	20.0	14.4	0.00	53.23	2302.21	111.9	6.000	3.115	105.9	108.8	0.930	0.897	57.85	41.32	0.975	0.972	56.40	40.15	0.226	0.803
14-Nov	55.58	2414.09	52.58	60.00	42.58	3	3	20.0	14.2	0.00	52.58	2302.21	111.9	6.000	3.021	105.9	108.9	0.930	0.895	57.85	40.61	0.975	0.971	56.40	39.45	0.226	0.789
15-Nov	54.96	2414.09	51.96	60.00	41.96	3	3	20.0	14.0	0.00	51.96	2302.20	111.9	6.000	2.935	105.9	109.0	0.930	0.892	57.85	39.94	0.975	0.971	56.40	38.79	0.226	0.776
16-Nov	54.21	2414.09	51.21	60.00	41.21	3	3	20.0	13.7	0.00	51.21	2302.20	111.9	6.000	2.831	105.9	109.1	0.930	0.887	57.84	39.04	0.975	0.971	56.40	37.90	0.226	0.758
17-Nov	53.56	2414.08	50.56	60.00	40.56	3	3	20.0	13.5	0.00	50.56	2302.20	111.9	6.000	2.742	105.9	109.1	0.930	0.883	57.84	38.27	0.975	0.970	56.40	37.13	0.226	0.743
18-Nov	53.03	2414.08	50.03	60.00	40.03	3	3	20.0	13.3	0.00	50.03	2302.20	111.9	6.000	2.671	105.9	109.2	0.930	0.879	57.84	37.64	0.975	0.970	56.40	36.51	0.226	0.730
19-Nov	52.20	2414.08	49.20	60.00	39.20	3	2	20.0	19.6	0.00	49.20	2302.19	111.9	6.000	2.561	105.9	109.3	0.930	0.929	57.84	38.60	0.975	0.975	56.40	37.60	0.226	0.752
20-Nov	51.62	2414.07	48.62	60.00	38.62	3	2	20.0	19.3	0.00	48.62	2302.19	111.9	6.000	2.486	105.9	109.4	0.930	0.929	57.84	38.43	0.975	0.975	56.40	37.47	0.226	0.749
21-Nov	51.23	2414.07	48.23	60.00	38.23	3	2	20.0	19.1	0.00	48.23	2302.19	111.9	6.000	2.436	105.9	109.4	0.930	0.929	57.84	38.04	0.975	0.975	56.40	37.09	0.226	0.742
22-Nov	50.59	2414.07	47.59	60.00	37.59	3	2	20.0	18.8	0.00	47.59	2302.19	111.9	6.000	2.355	105.9	109.5	0.930	0.928	57.84	37.42	0.975	0.975	56.40	36.48	0.226	0.730
23-Nov	50.04	2414.07	47.04	60.00	37.04	3	2	20.0	18.5	0.00	47.04	2302.18	111.9	6.000	2.287	105.9	109.6	0.930	0.928	57.84	36.87	0.975	0.975	56.40	35.95	0.226	0.719
24-Nov	49.50	2414.06	46.50	60.00	36.50	3	2	20.0	18.2	0.00	46.50	2302.18	111.9	6.000	2.220	105.9	109.7	0.930	0.927	57.84	36.34	0.975	0.975	56.40	35.42	0.226	0.708
25-Nov	48.99	2414.06	45.99	60.00	35.99	3	2	20.0	18.0	0.00	45.99	2302.18	111.9	6.000	2.159	105.9	109.7	0.930	0.927	57.84	35.84	0.975	0.975	56.39	34.94	0.226	0.699
26-Nov	48.44	2414.06	45.44	60.00	35.44	3	2	20.0	17.7	0.00	45.44	2302.18	111.9	6.000	2.094	105.9	109.8	0.930	0.925	57.84	35.25	0.975	0.975	56.39	34.37	0.226	0.687
27-Nov	47.86	2414.05	44.86	60.00	34.86	3	2	20.0	17.4	0.00	44.86	2302.18	111.9	6.000	2.025	105.9	109.9	0.930	0.924	57.84	34.63	0.975	0.975	56.39	33.76	0.226	0.675
28-Nov	47.28	2414.05	44.28	60.00	34.28	3	2	20.0	17.1	0.00	44.28	2302.17	111.9	6.000	1.959	105.9	109.9	0.930	0.922	57.84	34.02	0.975	0.975	56.39	33.16	0.226	0.663
29-Nov	46.71	2414.05	43.71	60.00	33.71	3	2	20.0	16.9	0.00	43.71	2302.17	111.9	6.000	1.894	105.9	110.0	0.930	0.921	57.84	33.42	0.975	0.974	56.39	32.56	0.226	0.651
30-Nov	46.22	2414.05	43.22	60.00	33.22	3	2	20.0	16.6	0.00	43.22	2302.17	111.9	6.000	1.839	105.9	110.0	0.930	0.919	57.84	32.89	0.975	0.974	56.39	32.05	0.226	0.641
01-Dec	45.87	2414.04	42.87	60.00	32.87	3	2	20.0	16.4	0.00	42.87	2302.17	111.9	6.000	1.800	105.9	110.1	0.930	0.918	57.84	32.52	0.975	0.974	56.39	31.68	0.226	0.634
02-Dec	45.42	2414.04	42.42	60.00	32.42	3	2	20.0	16.2	0.00	42.42	2302.17	111.9	6.000	1.752	105.9	110.1	0.930	0.917	57.84	32.05	0.975	0.974	56.39	31.22	0.226	0.624
03-Dec	44.89	2414.04	41.89	60.00	31.89	3	2	20.0	15.9	0.00	41.89	2302.16	111.9	6.000	1.695	105.9	110.2	0.930	0.915	57.84	31.49	0.975	0.974	56.39	30.66	0.226	0.613
04-Dec	44.45	2414.04	41.45	60.00	31.45	3	2	20.0	15.7	0.00	41.45	2302.16	111.9	6.000	1.648	105.9	110.2	0.930	0.913	57.84	30.97	0.975	0.974	56.39	30.15	0.226	0.603
05-Dec	44.10	2414.03	41.10	60.00	31.10	3	2	20.0	15.5	0.00	41.10	2302.16	111.9	6.000	1.612	105.9	110.3	0.930	0.911	57.84	30.57	0.975	0.973	56.39	29.76	0.226	0.595
06-Dec	43.71	2414.03	40.71	60.00	30.71	3	2	20.0	15.4	0.00	40.71	2302.16	111.9	6.000	1.572	105.9	110.3	0.930	0.908	57.84	30.13	0.975	0.973	56.39	29.32	0.226	0.586
07-Dec	43.27	2414.03	40.27	60.00	30.27	3	2	20.0	15.1	0.00	40.27	2302.16	111.9	6.000	1.527	105.9	110.3	0.930	0.906	57.84	29.62	0.975	0.973	56.39	28.81	0.226	0.576
08-Dec	42.94	2414.03	39.94	60.00	29.94	3	2	20.0	15.0	0.00	39.94	2302.16	111.9	6.000	1.494	105.9	110.4	0.930	0.904	57.84	29.24	0.975	0.973	56.39	28.44	0.226	0.569
09-Dec	42.50	2414.03	39.50	60.00	29.50	3	2	20.0	14.8	0.00	39.50	2302.16	111.9	6.000	1.451	105.9	110.4	0.930	0.901	57.84	28.74	0.975	0.972	56.39	27.95	0.226	0.559
10-Dec	42.24	2414.02	39.24	60.00	29.24	3	2	20.0	14.6	0.00	39.24	2302.15	111.9	6.000	1.425	105.9	110.4	0.930	0.900	57.84	28.44	0.975	0.972	56.39	27.65	0.226	0.553
11-Dec	41.89	2414.02	38.89	60.00	28.89	3	2	20.0	14.4	0.00	38.89	2302.15	111.9	6.000	1.391	105.9	110.5	0.930	0.898	57.84	28.05	0.975	0.972	56.39	27.26	0.226	0.545
12-Dec	41.46	2414.02	38.46	60.00	28.46	3	2	20.0	14.2	0.00	38.46	2302.15	111.9	6.000	1.350	105.9	110.5	0.930	0.895	57.84	27.57	0.975	0.972	56.39	26.79	0.226	0.536
13-Dec	41.20	2414.02	38.20	60.00	28.20	3	2	20.0	14.1	0.00	38.20	2302.15	111.9	6.000	1.326	105.9	110.5	0.930	0.894	57.84	27.28	0.975	0.972	56.39	26.50	0.226	0.530
14-Dec	40.89	2414.02	37.89	60.00	27.89	3	2	20.0	13.9	0.00	37.89	2302.15	111.9	6.000	1.297	105.9	110.6	0.930	0.891	57.84	26.92	0.975	0.971	56.39	26.15	0.226	0.523
15-Dec	40.64	2414.02	37.64	60.00	27.64	3	2	20.0	13.8	0.00	37.64	2302.15	111.9	6.000	1.274	105.9	110.6	0.930	0.889	57.83	26.61	0.975	0.971	56.39	25.84	0.226	0.517

Day	River Flows at Weir (cumecs)	Head Water Level (m)	Flows less Ecological Flows (cumecs)	Plant Peak Discharge (cumecs)	Plant Off-Peak Discharge (cumecs)	No. of Turbines in Operation for Peaking	No. of Turbines in Operation for Off-Peaking	Discharge Per Turbine of Peaking Plant (cumecs)	Discharge Per Turbine of Peaking Plant (cumecs)	Spilled Discharge (cumecs)	Hunza River Flows at PH (cumecs)	TWL (masl)	Gross Head (m)	Head Loss Peaking Plant (m)	Head Loss Off-Peaking Plant (m)	Net Head Peaking Plant (m)	Net Head Off-Peaking Plant (m)	Turb Eff. For Peaking Turbines	Turb Eff. For Peaking Turbines	Peaking Turbines Output (MW)	Off-Peaking Turbines Output (MW)	Peaking Generator Efficiency	Off-Peaking Generator Efficiency	Peaking Generators Output (MW)	Off-Peaking Generators Output (MW)	Peaking Plant Energy at Generator Terminal (GWh)	Off-Peaking Plant Energy at Generator Terminal (GWh)
16-Dec	40.53	2414.02	37.53	60.00	27.53	3	2	20.0	13.8	0.00	37.53	2302.15	111.9	6.000	1.263	105.9	110.6	0.930	0.888	57.83	26.47	0.975	0.971	56.39	25.70	0.226	0.514
17-Dec	40.22	2414.01	37.22	60.00	27.22	3	2	20.0	13.6	0.00	37.22	2302.15	111.9	6.000	1.235	105.9	110.6	0.930	0.885	57.83	26.08	0.975	0.971	56.39	25.32	0.226	0.506
18-Dec	40.05	2414.01	37.05	60.00	27.05	3	2	20.0	13.5	0.00	37.05	2302.15	111.9	6.000	1.220	105.9	110.6	0.930	0.883	57.83	25.88	0.975	0.971	56.39	25.12	0.226	0.502
19-Dec	39.71	2414.01	36.71	60.00	26.71	3	2	20.0	13.4	0.00	36.71	2302.14	111.9	6.000	1.189	105.9	110.7	0.930	0.880	57.83	25.46	0.975	0.970	56.39	24.70	0.226	0.494
20-Dec	39.28	2414.01	36.28	60.00	26.28	3	2	20.0	13.1	0.00	36.28	2302.14	111.9	6.000	1.151	105.9	110.7	0.930	0.875	57.83	24.93	0.975	0.970	56.39	24.18	0.226	0.484
21-Dec	38.84	2414.01	35.84	60.00	25.84	3	2	20.0	12.9	0.00	35.84	2302.14	111.9	6.000	1.113	105.9	110.8	0.930	0.871	57.83	24.41	0.975	0.969	56.39	23.66	0.226	0.473
22-Dec	38.52	2414.01	35.52	60.00	25.52	3	2	20.0	12.8	0.00	35.52	2302.14	111.9	6.000	1.085	105.9	110.8	0.930	0.868	57.83	24.01	0.975	0.969	56.39	23.27	0.226	0.465
23-Dec	38.29	2414.00	35.29	60.00	25.29	3	2	20.0	12.6	0.00	35.29	2302.14	111.9	6.000	1.066	105.9	110.8	0.930	0.865	57.83	23.75	0.975	0.969	56.39	23.00	0.226	0.460
24-Dec	38.04	2414.00	35.04	60.00	25.04	3	2	20.0	12.5	0.00	35.04	2302.14	111.9	6.000	1.045	105.9	110.8	0.930	0.863	57.83	23.44	0.975	0.969	56.39	22.70	0.226	0.454
25-Dec	37.75	2414.00	34.75	60.00	24.75	3	2	20.0	12.4	0.00	34.75	2302.14	111.9	6.000	1.021	105.9	110.8	0.930	0.860	57.83	23.09	0.975	0.968	56.39	22.36	0.226	0.447
26-Dec	37.46	2414.00	34.46	60.00	24.46	3	2	20.0	12.2	0.00	34.46	2302.14	111.9	6.000	0.997	105.9	110.9	0.930	0.857	57.83	22.75	0.975	0.968	56.39	22.02	0.226	0.440
27-Dec	37.05	2414.00	34.05	60.00	24.05	3	2	20.0	12.0	0.00	34.05	2302.13	111.9	6.000	0.964	105.9	110.9	0.930	0.853	57.83	22.28	0.975	0.967	56.39	21.55	0.226	0.431
28-Dec	36.75	2414.00	33.75	60.00	23.75	3	2	20.0	11.9	0.00	33.75	2302.13	111.9	6.000	0.940	105.9	110.9	0.930	0.849	57.83	21.89	0.975	0.967	56.39	21.17	0.226	0.423
29-Dec	36.55	2413.99	33.55	60.00	23.55	3	2	20.0	11.8	0.00	33.55	2302.13	111.9	6.000	0.924	105.9	110.9	0.930	0.846	57.83	21.63	0.975	0.967	56.39	20.91	0.226	0.418
30-Dec	36.25	2413.99	33.25	60.00	23.25	3	2	20.0	11.6	0.00	33.25	2302.13	111.9	6.000	0.901	105.9	111.0	0.930	0.841	57.83	21.24	0.975	0.966	56.39	20.53	0.226	0.411
31-Dec	36.01	2413.99	33.01	60.00	23.01	3	2	20.0	11.5	0.00	33.01	2302.13	111.9	6.000	0.883	105.9	111.0	0.930	0.838	57.83	20.94	0.975	0.966	56.39	20.23	0.226	0.405
Note: Plant Auxiliary Load, Scheduled & Forced Outages are not considered																										***82.392***	***294.764***

Table 11.2: Comparison of FSR (2021) and Review Report Parameters

Description	Feasibility Study Report, 2021, Conducted by WAPDA	Review Report (AHMC)
Plant Design Discharge (m^3/s)	60	60
Gross Head (m)	112	111.9 ~112
Installed Capacity (MW)	54	56.4
Mean Annual Energy (GWh)	373.69	377.16*
Plant Factor (%)	79	76.3

*(Using mean of daily flow data for the years 1966 to 2015)

Table 11.3 Comparison of FSR (2021) and FSR (2017) Parameters

Power and Energy Parameters	As in Feasibility Study 2017, Conducted through Consultants	As in Feasibility Study, 2021, Conducted by WAPDA
Design Discharge (m^3/s)	40	60
Gross Head (m)	106	112
Power Capacity (MW)	32.5	54
Mean Annual Energy (GWh)	256.66	373.69
Plant Factor (%)	92.7	79

11.2 GOVERNOR SYSTEM

Feasibility study states compressed air charged bladder type pressure accumulator for governor pressure oil system, however as per present international practice, Nitrogen charged bladder type pressure accumulators are more frequently used for such purpose. Hence, we recommend to keep both the options open for the contractor.

11.3 INLET VALVE

Butterfly type valves to serve as shut off for turbines mentioned in the feasibility study report (FSR) are suitable regarding head, cost, maintenance and performance.

Under clause 11.13, the word “cast steel” written against sealing system need to be replaced with “Rubber seal / Stainless steel seat”.

In clauses 9.11.2 & 15.8.11, spherical valves need to be replaced with butterfly valves.

11.4 MECHANICAL AUXILIARY SYSTEMS

Mechanical auxiliary systems play vital role in almost every hydropower plant for its successful operation. Some of the mechanical auxiliary systems mentioned in the feasibility study report have been rationalized / added which are specified in the subsequent paragraphs.

11.4.1 Cooling Water System

Feasibility study report is silent about the provision of cooling water system which is considered integral part of a hydropower plant mechanical auxiliary system. A cooling water system will be installed in the powerhouse to supply sufficient cooling water for:

- Generator oil coolers.
- Oil coolers of turbine and Generator bearings.
- Turbine shaft seal.
- Governor (if required).

An open loop cooling system shall be provided for Attabad Hydropower station. Cooling water shall be directly taken from each penstock branch and run through a Coarse - Duplex Strainer and connected to a common raw water header through isolating valves.

Each unit will be equipped with its own cooling water system, but these will be interconnected to facilitate maintenance of the system and the operation during part-load operation during the winter season.

Water for the shaft seal will be taken from the downstream side of the cooling water filter system, passed through a fine-filter and then transferred to the shaft seal for cooling.

11.4.2 Oil Handling System

In the feasibility study report, stationary type oil filtration plant (centralized oil purification / handling system) is provided for turbine oil system. We do not anticipate to have centralized oil handling system for such size of plants and recommend to eliminate it. Instead, mobile / portable oil purifier provided to filter / purify the lubricating / hydraulic oil is sufficient. We also recommend to use common grade of oil for the unit lubrication and governor pressurized oil system to facilitate the delivery of oil when replacement oil is required. Provision will be made to guard against water pollution resulting from accidental oil spills in the powerhouse.

11.4.3 Fire Protection System

In clause 11.14.11, feasibility study states: “Oil storage rooms shall also be provided with CO^2 filled cylinders with auto release system initiated by smoke and fire detectors installed in the room”. We do not agree to provide auto release CO^2 for oil storage area due to safety hazard for humans and recommend to replace it with automatic water spray system. Water spray system shall also be provided for cable gallery. Additionally, foam fire-extinguishers will be provided at strategic locations in the oil storage and cable gallery areas.

In table 11.4 of feasibility report serial number 2 & 3, fire protection system for GIS building and Penstock Valve House are mentioned whereas there is no GIS building and Penstock valve house in the project. This needs to be corrected.

NFPA 851, Recommended Practice for Fire Protection for Hydroelectric Generating Plants mentioned in the report has been merged with NFPA 850, Recommended Practice for Fire

Protection for Electric Generating Plants and High Voltage Direct Current Converter Stations. Hence NFPA 850 will be applied.

- **Fire Water Supply**

Overhead tank/s to fulfill water requirement as per NFPA-850 will be provided. The contractor shall submit overhead tank/s design along with proposal for its location for approval of the owner / owner's representative.

11.5 POWERHOUSE (PH) LAYOUT

Discrepancy regarding powerhouse dimensions is found, in clause 9.11.2 of Main Report Powerhouse dimensions are L-63 x W-20 x H-35 meters whereas in drawings the dimensions are L-45 x W-17.8 x H-22.5 meters (from foundation to crane corbel level).

After analyses of these dimensions, we recommend following changes / improvements:

- PH length (including loading/unloading bay) of 45m mentioned in the drawings should be increased to 52m. Unit center to center distance should be increased from 10m to 11m.
- Inner width of machine hall 14.5m should be increased to 15m, however total width of PH has to be increased from 17.8m to 29m excluding upstream and downstream walls for creating sufficient space to adjust auxiliary E&M equipment and other necessary areas in the PH.
- Machine hall floor level should be changed from 2306.2 m to 2308.0m, however other levels seem appropriate.
- In PH X-section drawing, the height of PH from foundation to crane corbel should be increased from 22.5m to 23.0m (revised corbel level will become 2322m). The height from crane corbel to roof inner level is not mentioned, however after consulting manufacturers' catalogues, we recommend that it should be at least 3.5m for EOT crane installation and availability of sufficient head space for its future maintenance. Inner roof level will be 2325.5m.
- The provision of draft tube stoplogs upstream of draft tube gates as shown in the powerhouse layout drawings are considered unnecessary.

11.6 PENSTOCK

Fewer details are provided in the feasibility study report regarding penstock. Certain shortcomings are also noted which are mentioned hereunder.

- Inconsistencies found with regards to penstock diameter and length in the main report and drawings which need correction.
- Material for steel penstock is missing. We recommend that material of penstock including branches and manifold shall be pressure vessel steel conforming to ASTM A516 Gr-70 or other equivalent international standard subject to approval of the owner or owner's representative. If thickness of any part of the penstock exceeds 38mm, normalized material shall be provided.
- Nothing is mentioned about length of each penstock branch, however diameter of 2.1m is specified which shall be rounded off to 2.0m. Each branch ends at connection with main inlet valve of 1.83m dia. via reducer.
- Sleeve type expansion joints are missing which shall be provided after each anchor block.

- Hold down straps for exposed penstock are missing which shall be provided.

11.7 HYDRAULIC STEEL STRUCTURES

11.7.1 General

This section includes the function, performance criteria and certain shortcomings which are mentioned in the subsequent paragraphs. Fewer details are provided in the feasibility study report regarding gates, stoplogs and trashracks. Also, proper description of civil structure for installation of Hydraulic steel structures (HSS) are not provided. However, all the civil structures for which Hydraulic steel structure will be installed are as flowing:

1. Power Intake Structure

- Power Intake Gates
- Power intake Stoplogs
- Power Intake Trash rack

2. Weir Structure

- Flushing Section Gate
- Flushing Section Stoplogs

3. Tailrace Structure

- Draft Tube Gate

11.7.2 Power Intake Structure

Twin intakes have been provided with gates and a set of stoplogs for control of water intake into the power waterway system. Two bays are provided at each waterway structure with trash rack required at the entrance to prevent entry of debris into the power waterway system. Hence, as per Vol-II -drawings there will be four sets of trash racks whereas in main report only one set is mentioned. The equipment provided at power intake will be as following:

1. Two (2) hydraulically operated fixed wheel gates.
2. One (1) set of stoplogs at upstream of Gate.
3. Four (4) sets of Trash racks at entrance of each bay.
4. One Trashrack cleaning machine.
5. One gantry crane operating on a runway spanning the entire structure will be provided for maintenance of intake gates and stoplogs.

- **Power Intake Gates**

Power intake Gates must control the flow into the headrace tunnel during filling of the waterways and isolate the reservoir from the waterway for inspection and maintenance of the waterway. Therefore, at each power intake structure one Fixed Wheel Gate will be installed, which will act as Emergency gate and fulfilling aforementioned controls. Each gate will be operated by oil hydraulic servomotor. For each set of maintenance / service gates a common oil pressure unit has been considered. Moreover, the oil pressure units will be interconnected to each other in order to promote safety.

Main Data:

Type of Gate	Fixed Wheel Gate
Number of Gate Openings	Two (2)
Number of Gates	Two (2), one in each waterway

Number of embedded parts	Two sets
Type of Hoist	Hydraulic Cylinder
Approximate head on gate sill	~18.5m
Sealing	Four Sided

- **Power Intake Stoplogs**

One set of steel stoplogs will be provided at immediately upstream of each intake gate. It will be lowered when inspection or maintenance of the intake gate is required. The upper panel of stoplog will be provided with a filling valve in order to rise the stoplogs under balance condition. The stop log will be raised and lowered by a rail mounted gantry crane.

Main Data:

Type of Stoplogs	Vertical Slide
Number of Sets	One set
Handling of Stoplogs	25t Gantry Crane with lifting beam
Approximate head on gate sill	~18.5m
Sealing	Four Sided

- **Power Intake Trash rack**

A trash rack will cover the entrance to each power intake. The trash racks will be of the non-withdrawal type, consisting of fixed inclined trash rack panels supported by streamlined cross beams. The trash rack panels and the corresponding supporting structures will be designed to withstand the design pressure with a safety factor of 1.5. The bars of the trash racks will be spaced so as to block floating debris large enough to damage the turbines. This way floating debris is prevented from entering the waterway.

A trash rack cleaning machine mounted on rails on the intake structure deck will remove trash and debris collected by the trash racks.

Type of Trash rack	Inclined, Fixed type
Number of Sets	4 sets
Handling of Trash racks	initially with mobile crane and afterwards with the help of winch machine provided with cleaning machine
Cleaning of Trash racks	Trash rack Cleaning Machine (pay load capacity = 1 Ton)

11.7.3 Weir (Sediment Flushing Channel / Under sluice)

Following hydraulic steel structures are provided in the FSR:

1. Three (3) hydraulically operated Radial gates.

2. One Set of Stoplogs at upstream of Gate.

3. One set of Stoplog at downstream of Gate

As the under sluices utilized for sediment flushing are being avoided in the proposed alternative layout due to geotechnical issues in this review report, therefore, above gates and stoplogs will be excluded.

- **Alternative Flushing Tunnel**

To flush out sediment that is likely to be deposited in front of the intake structure, a new tunnel of 5.5m diameter is proposed in this review report. The flushing tunnel intake will be placed near the power tunnel intake at a distance of about 7m and at a lower level than the power intake structure. It is proposed that flushing tunnel intake will be similar to power tunnel intake and have following hydraulic steel structures (starting from upstream).

- One set of vertical lift maintenance stoplogs, (welded steel structure) handled by Gantry crane / EOT crane.
- One vertical lift fixed wheel gate to control water having hydraulic type hoist (quantity of the gates will be decided during detail design stage).
- One no. gantry / EOT crane (for installation and handling of stoplogs; installation of gate and its removal for future maintenance).

During detail design stage, the EPC Contractor will design and prepare arrangement of flushing tunnel intake structure (including HSS design) viewing best engineering practices subject to approval of the Employer / MC.

11.7.4 Tail race Structure

- **Draft tube Gate**

The draft tube of each turbine unit will be provided with (01) vertical lift bulkhead gate in order to dewater the turbine for installation, maintenance, inspection and repair of turbines. The operation shall be under balance head condition (created through filling valves) with the help of electric overhead travelling crane. The provision of draft tube stoplogs is uncertain/confusing as mention in main report clause 11.15.7.2 and also depicted /shown on drawing (AFS-PH-435), but not included in scope at any other part of report. Provision of stoplog along with bulkhead gate will be unnecessary as the draft tube gate will be enough to fulfill the above mentioned requirements.

Type of Gate	Vertical lift bulkhead type with filling valve
Number of Gate Openings	Three (3)
Number of Gates	Three (3)
Number of embedded parts	Three sets
Type of Hoist	Overhead travelling crane with lifting beam
Approximate head on gate sill	~12m
Sealing	Four Sided

11.8 SUMMARY OF REVIEW FINDINGS

A summary of Review findings for Hydromechanical studies is presented in Table 11.4

TABLE 11.4: Summary of Hydraulic Steel Structures Mentioned in the FSR (2021) and Shortcomings Identified in the Review Remarks									
Description	**Type of HSS**	**Qty.**	**Embedded Parts Qty.**	**Clear Opening Dimensions (W x H)**	**Water Level (m)**	**Sill Elevation (m)**	**Head (m)**	**Type of Hoist**	**Shortcomings Identified in the FSR and Review Report Remarks**
Power Intake									
Power intake gate	Fixed Wheel Gate	2 Nos.	2 Set	4m x 5m		El. 2402.50	18.5	Hydraulic cylinders	
Power intake Trashrack	Inclined Fixed/non-withdrawal type	1 set	1 Set	4.5m x 5m		El. 2404.0		Mobile crane	There are 4 no. of bays/ intakes for which at least 4 sets of trash racks are required, whereas in main report table 11-9 only 1 set is mentioned.
Power intake Stoplogs	Vertical slide	2 set	2 Set	4m x 5m		El. 2402.50	18.5	Gantry crane (rail mounted) or mobile crane by lifting beam	
Trash rack cleaning machine									
Gantry Crane (25t)	Electrically operated Gantry Crane	1							

TABLE 11.4: Summary of Hydraulic Steel Structures Mentioned in the FSR (2021) and Shortcomings Identified in the Review Remarks									
Description	**Type of HSS**	**Qty.**	**Embedded Parts Qty.**	**Clear Opening Dimensions (W x H)**	**Water Level (m)**	**Sill Elevation (m)**	**Head (m)**	**Type of Hoist**	**Shortcomings Identified in the FSR and Review Report Remarks**
Weir (Sediment Flushing Channel / Under sluice)									
As the under sluices utilized for sediment flushing are being avoided in the proposed alternative layout due to geotechnical issues in this review report, therefore, above gates and stoplogs will be excluded.									
Alternate Flushing Tunnel									
Stoplogs	Vertical Slide Type	1 set	1 Set					Gantry / EOT Crane	The Gantry crane provided for handling of power intake stoplogs same will be utilize for handling of flushing tunnel stoplogs.
Intake Gate	Fixed Wheel Gate	1 no.	1 Set					Hydraulic cylinders	
Gantry / EOT Crane	Electrically operated	1 no.							
Tailrace Structure									
Draft tube Bulkhead Gate with filling valves	Vertical lift Bulkhead	4	3	3m (H)		El.2295.00		Overhead Travelling Crane	For three draft tube openings, four gates are provided which need to be corrected as three. It is written: “One electrically operated overhead travelling crane will be provided for handling the draft tube gates and inlet stoplogs of tailrace tunnels with the help of lifting beams.” This is incorrect, there are no tailrace tunnels and so the stoplogs. This need correction.

12 REVIEW OF ELECTRICAL EQUIPMENT STUDIES

12.1 GENERAL

Electrical equipment general layout / arrangement drawings are missing in Feasibility Study Report (FSR). The same will be added during preparation of Draft EPC Tender Documents. It is assumed that there is no problem regarding transportation of heavy construction and permanent equipment as mentioned in Section 1.6 of FSR, “Access to the Project Area”

Reference Standards details for each electrical equipment are missing in FSR. All equipment under these Technical Specifications will be manufactured and tested in accordance with the latest revision of IEC/IEEE/BS/ASTM international standards. The same will be added for each Electrical Powerhouse Equipment during Draft EPC Tender Documents.

In general, there are many contradictory statements in the Feasibility Study Report (FSR). Discrepancies found during Feasibility Review for each Electrical Powerhouse Equipment are described in following sections.

12.2 REVIEW OF POWERHOUSE ELECTRICAL WORKS STUDIES

The Electrical Equipment/Components of the Powerhouse are as below.

- Generators & Excitation System(s)
- Generator Circuit Breaker(s)
- Power Transformer(s)
- Station Service Transformer(s)
- Unit Auxiliary Transformer(s)
- Medium & Low Voltage Switchgear(s)
- Control & Instrumentation System
- Protection & Relay System
- DC & UPS System
- Cables
- Illumination & Small Power System
- Emergency Diesel Generator (EDG)
- Electrical Workshop
- Earthing and Lightning Protection System
- Fire Detection and Alarm System

12.2.1 Generator & Excitation System

Under section 12.3, of FSR, it is mentioned that *“A flywheel of suitable inertia will also be mounted on the same shaft to keep the constant speed of the generator & avoiding the fluctuations/harmonics resulting from varying loads and switching surges.”* This statement is not valid for Project of this size and will be deleted.

Under section 12.3, following specified in FSR *“Generator terminals are connected by isolated phase bus (IPB) to Generator circuit breaker (GCB).”* Isolated phase bus duct is utilized for large size generators with higher current rating. This section needs to be reviewed during preparation of Draft EPC Tender Documents.

Under Table 12-1, power factor 0.85 is specified. As per requirement of Pakistan Grid Code, power factor range for generator should be 0.8 lagging to 0.9 leading. Power factor needs to be corrected during preparation of Draft EPC Tender Documents.

Under Section 12.3.2, following is specified in FSR, *"The generators are capable to run at 15% continuous overload without exceeding the temperature limits of class F insulation."* This statement is not supported in any international standard and it shall be deleted.

Under Table 12-1, Nominal capacity of each generator is given as 21.2MVA (18MW). Considering the efficiency of turbine 93% instead of 91.5%, the generators nominal capacity and associated equipment rating will be revised and provided in the draft EPC bidding documents.

12.2.2 Generator Circuit Breaker

Under 12.1, 2nd para, 2 GCBs are mentioned, whereas in 3rd para, it is mentioned that *"The generators shall be connected to their respective unit transformers (three phase) through GCB (3 GCBs).* However, all three generators are connected through circuit breakers (commonly known as GCB) to Unit transformers and the same shall be provided in the draft bidding documents.

12.2.3 Power Transformer

Under Section 12.5, following specified in FSR, *"An allowance of 10% continuous overload is also proposed."* This statement needs to be checked and verified in accordance with requirement specified in IEC 60076.

Under Table 12-2, transformer nominal capacity 22MVA specified. This is not standard rating for power transformer. MC will provide the generator step-up transformer rating in the draft EPC bidding documents in accordance with the generator rated capacity.

Under Table 12-2, OFF Load Tap changer is specified. It is highly recommended to specify an ON-Load Tap Changer for power transformer and the same shall be proposed during preparation of Draft EPC Tender Documents.

There is no explosion prevention system specified for power transformer. The same will be considered during preparation of Draft EPC Tender Documents.

12.2.4 Station Service Transformer

Under section 12.6, one (01) No. Station Service Transformer has been proposed with 2 MVA capacity, 11/132 kV voltage rating, ONAN cooling and Dry/Oil Type. ONAN cooling with Dry type is not correct. This section needs to be reviewed during preparation of Draft EPC Tender Documents.

12.2.5 Unit Auxiliary Transformers

Under section 12.7, two (02) No. Unit Auxiliary Transformers have been proposed each with 630 kVA capacity, 11/0.4 kV voltage rating and ONAN cooling type.

For Unit Auxiliary Transformers, MC recommend to use Dry Type Transformers. MC will provide the three-unit auxiliary transformers along with the vector group in the draft EPC bidding documents.

Under section 12.7, two (02) No. Auxiliary Transformers have been proposed each with 400 kVA capacity, 11/0.4 kV voltage rating and ONAN cooling type.

Impedance of 4% for these type of transformers needs to be reviewed during preparation of Draft EPC Tender Documents. Vector Group is also missing for these transformers.

12.2.6 Medium & Low Voltage System

- **Powerhouse**

Under section 12.8.2, it has been mentioned that switchgear planned to be located in a separate room in the 132 kV switchyard. This statement needs to be reviewed during preparation of Draft EPC Tender Documents.

Under Section 12.8.2, it has been mentioned that there are some 11kV feeders to supply power to rural areas. In this regard, MC will not consider the provision of 11kV feeders from Attabad plant in draft EPC bidding documents. It is recommended to power-up the nearby rural areas from the local grid.

Under section 12.8.2, There are some important parameters of MV Switchgear which are missing and needs to be specified e.g. LSIG Digital Trips, Protection Class, Busbar Material, Continuous Current of Bus and Bus bar Insulation etc.

The details of CT, PT etc. are missing in the report which needs to be augmented during preparation of Draft EPC Tender Documents.

Under section 12.8.2, Single Line Diagram and Rated Short Circuit Current needs to be verified during preparation of Draft EPC Tender Documents.

- **Medium and Low Voltage AC Supply**

Under Main Single Line Diagram, 0.85 Power Factor has been specified which needs to be corrected as 0.8 lagging, 0.9 leading as per NEPRA Grid Code.

Under section 12.8.3, there are some important parameters of LV Switchgear which are missing and needs to be specified e.g. LSIG Digital Trips, Protection Class, Busbar Material, Continuous Current of Bus, Bus bar Insulation and Separation class as per IEC for LV Switchgear etc.

Further, Station Service Transformer capacities and quantities will be verified during preparation of Draft EPC Tender Documents.

There is nothing stated in FSR about Motor Control Centres (MCCs). We recommend to add the details of the same during preparation of Draft EPC Tender Documents.

12.2.7 Control & Instrumentation System

Under Section 12.19.2, MC will not consider the provision of control and instrumentation system for the spillway/weir in the draft EPC bidding documents as it is mentioned in section (18) that the ungated spillways shall be proposed.

Under Section 12.19.3, comprehensive detail is mentioned regarding interface of Attabad Lake HPP with Existing NTDC/NPCC SCADA System. However, in Section 13.2 of this report it is mentioned that entire region of Gilgit Baltistan is not connected with the national grid due to its mountainous terrain. Even there is no any Regional Load Dispatch Centre available in the entire region. This mismatch needs to be clarified.

MC understand that currently there is no Regional Load Dispatch Centre or NTDC/NPCC SCADA System exists/available in the entire region. At this stage, we only require to have provision of SCADA System for providing future interlinking with Regional Load Dispatch

Centre or NTDC/NPCC SCADA System (future provision). The tele-control gateway shall be used for communication with Regional Load Dispatch Centre or NTDC/NPCC SCADA System.

General description regarding the design philosophy of the Plant Control System (PCS) and main functions/features of the Unit Local Control Panels (ULCPs), Local Control Panels (LCPs), Operator Workstation, Engineering Workstation etc. are not specified. The same will be specified during preparation of Draft EPC Tender Documents.

Automatic Load Frequency Control (ALFC) of generators from the NPCC is mentioned. We recommended that this requirement is not necessary for Attabad Lake HPP.

Under Section 12.19.1, it is mentioned that the generating unit operation will be carried out **remotely** from the machine hall floor level of the **underground powerhouse**. However, in Section 7.1, it is mentioned that **surface powerhouse** is viable at site.

MC will provide the specifications for surface powerhouse in the draft EPC bidding documents.

12.2.8 Protection Equipment

Under Section 12.9.2, it is specified that all relays shall preferably be of the same make (manufacturer) to build a uniform modular system. While the next para specified that general principal for the protection is that all parts of installation are covered by two high speed protection schemes which are independent to avoid common mode failures. These two requirements contradict each other and shall be corrected. Protection schemes whether “Primary & Backup” OR “Duplicate Protection” will be re-evaluated during preparation of Draft EPC Tender Documents.

Instrument transformers requirements for protection equipment is not specified.

There are some protections, which are not specified in FSR. All required protections shall be considered during preparation of Draft EPC Tender Documents.

12.2.9 DC & UPS System

Under section 12.13, one 220V battery system, with one main distribution switchgear and battery charger is proposed in FSR. The proposed scheme in FSR and as shown on single line diagram is not suitable and reliable. Moreover, there is no backup system for Emergency Lighting System covered in FSR.

We recommend 220 V DC supply system with two (02) no. DC distribution boards, two (02) no. Rectifiers, one (01) no. battery bank of ample capacity and two (02) no. battery chargers. Where 48 V DC or 24 V DC voltage is required, DC/DC converters shall be used. 220 V DC distribution boards shall be fed from 400 VAC switchgear through rectifiers.

Regarding UPS, we recommend one (01) no. 230 V AC UPS System. Normally UPS will be fed from 400 AC Switchgear. In case of failure of normal power supply, UPS will be fed from 220 V DC supply system through two (02) No. DC/AC inverters. The recommended scheme for UPS will be specified during preparation of Draft EPC Tender Documents.

12.2.10 Cables

Under Section 12.14, technical parameters of cables are missing. We recommend to add the technical parameters of cables during preparation of Draft EPC Tender Documents.

12.2.11 Illumination & Small Power System

Under Section 12.15, LED lighting system is mentioned in the start of the section. However, technical details of fluorescent light fittings are mentioned in this section.

MC will provide the specifications of LED lighting system in the draft EPC bidding documents.

12.2.12 Emergency Diesel Generator

Under section 12.16, capacities and quantities of emergency diesel generators will be re-evaluated during preparation of Draft EPC Tender Documents keeping in view the loads of each area.

12.2.13 Electrical Workshop

Workshop details will be re-evaluated during preparation of Draft EPC Tender Documents.

12.2.14 Earthing & Lightning System

Under section 12.18, earthing system has been specified. Moreover, there is no earth resistance value specified. Further, lightning protection system is not covered in FSR which is an essential part of building/outdoor equipment protection.

We recommend earthing and lightning protection system for the powerhouse, switchyard and intake area with earthing resistance less than 1 ohm for each specific area. EPC contractor shall measure the earth resistivity and will perform earthing calculation in accordance with IEEE 80-2000 standard. The same will be specified during preparation of Draft EPC Tender Documents.

12.2.15 Fire Detection & Alarm System

Fire Detection & Alarm System is not specified in the FSR which will be added during preparation of Draft EPC Tender Documents.

12.2.16 Drawings

- **Single Line Diagrams**

Single Line Diagrams for Powerhouse, AC Distribution and other drawings needs to be reviewed / updated during preparation of Draft EPC Tender Documents.

- **Plant Control System Drawing (Asf-Em-455)**

The Plant Control System (PCS) drawing is not in-line / coordinated with the requirements specified in the relevant section of the FSR. Separate Control System for Auxiliaries and DC System are shown in the drawing and there is no description regarding the functionality of these Control Systems. Moreover, separate Control System for Intake/Tailrace is shown in the drawing which is incorrect as intake and tailrace are two separate and distant structures of the Project.

The updated / revised drawing of Conceptual Layout of Plant Control System (PCS) will be added during preparation of Draft EPC Tender Documents.

12.3 REVIEW OF SWITCHYARD STUDIES

12.3.1 Review Findings

Following are the review findings and comments for Switchyard studies carried out at Feasibility stage.

- Short circuit study is not available with us. However, we have considered short circuit rating of the equipment as 40kA as per latest practice of NTDC.
- Only the time frame of seven (07) months is mentioned for the construction of 132kV Switchyard. Kindly clarify us regarding the total time frame required/estimated for the completion of the 132kV Switchyard including preparation of Tender Documents, Evaluation of Bids, Award of Contract, Construction phase and Defects Liability Period etc.
- Proposed switchyard will be of 'Conventional AIS' type as mentioned in the Switchyard Main Single Line Diagram. It is noted that the word 'GIS' is mentioned at several places in the Feasibility Report for the type of 132kV Switchyard. We have considered 132kV AIS switchyard keeping in view the availability of land and difference in GIS price.
- The location of the switchyard shall be finalized during the detail design stage. However, the tentative location of 132kV switchyard will be provided in the draft EPC bidding documents.
- Bus coupler should be included as two different supplies will be connected with the 11kV busbar.
- Bus coupler should be provided for LV AC (400V) system.
- MC will provide the scope of remote end line bays (including Step-Down Transformers) in the Transmission lines (Lot-II) of draft EPC bidding documents.
- 132kV switchyard /switchgear control system will be based on IEC 61850 for SAS system with provision to control from DCS of power house.
- DC distribution panel to be provided in switchyard control room even D.C. supply feeder will be provided from power house.
- Clearances and equipment insulation levels to be coordinated with the altitude of switchyard area from sea level.
- 132/11kV power transformer MVA rating shall be coordinated with colony and other present & future load requirement as exact load of the power transformer is not available with us.
- MC understand that three (03) transmission line circuits (one double circuit transmission line circuit and one single circuit) with twin bundle rail conductor for 67MVA is more than requirement. Single circuit with single rail conductor per phase is enough for power evacuation. For (N-1) contingency maximum two circuit (one double circuit or two single circuit transmission lines) will serve the purpose. However, T/L Expert should decide the number of lines keeping in view the actual power transmission envisaged for future. We have considered single rail conductor/per phase for transmission line and 132kV switchyard equipment rating will be as under:
- 132kV Circuit Breaker (CB) 1250 A with 40kA short circuit rating
- 132kV Disconnector Switch (DS) 1250 A with 40kA short circuit rating
- 132kV Current Transformer (CT) 1250 A with 40kA short circuit rating
- 132kV busbar rating 2000 A with 40kA short circuit rating
- In case of any change in short circuit level and number of lines the configuration of 132kV switchyard and equipment rating have to be revised accordingly.

- Table 14-17 i.e. 'cost estimate for 132kV Switchyard Equipment' of 'Volume-I main report of feasibility study of Attabad lake HPP' indicates US $ price column as per the dollar exchange rate of 157 PKR. Prices should be revised as per the latest dollar exchange rate. Moreover, the cost of power transformer, tariff metering equipment and civil works shall be included.

12.3.2 Main Single Line Diagram and Protection Single Line Diagram

- **Main Single Line Diagram (ASF-EM-451)**
- Current transformers (CTs) have not been indicated on the main single line diagram (ASF-EM-451). The same shall also be included.
- 132kV Bus bars ratings have not been indicated on the drawing. These shall be as 2000A, 40kA and 145kV current carrying capacity, short circuit level and rated voltage level respectively.
- 132kV Bus bar VTs have not been indicated on the main single line diagram (ASF-EM-451). The same should be included.
- It is not clear whether tariff metering of 132/11kV power transformer will required or not.
- Disconnector switch at HV side of step-up transformer shall also to be included.
- Line earth switch shall be shifted toward line side.
- VT for synchronism check to be provided on HV side of step-up transformer.
- Line trap and CCVT have not been indicated on the main single line diagram (ASF-EM-451). The same should be indicated on the drawing.
- Secure metering system (SMS) equipment such as CTs and CVTs for main and backup tariff metering system to be included at HV side of each unit transformer.
- **Protection Single Line Diagram**

Protection scheme to be revised as detailed below.

132kV Transmission Line Protection

- Distance Set-I with built-in autoreclosure, fault recorder, over current, stub protection.
- Distance Set-II with built-in autoreclosure fault recorder, over current, stub protection.

132/11kV Transformer

- Transformer differential protection and over current protection shall also be included/indicated on the drawing.
- REF shall also be included/indicated on the drawing.

12.3.3 11/132kV Unit Transformer

- Differential Set-I with built in overflux thermal overload, REF, HV, neutral over current voltage restraint over current.
- Differential Set-II with built in overflux, thermal overload, neutral over current, HV over current, LV over current voltage restraint over current.
- Over current protection to protect stub area in case of both differential relays are out of service shall also be included/indicated on the drawing.

- Overall generator transformer differential is not required as per adopted scheme.
- Circuit breaker failure protection scheme should be included.
- 132kV centralized busbar protection should be included.
- Trip circuit supervision protection should also be included.

12.4 REVIEW OF DISTRIBUTION STUDIES

Following are the review findings and comments on Distribution studies carried out at Feasibility stage.

- Sizes of the Distribution Transformers/DG sets shall be finalized at the detailed designing stage keeping in view the exact normal/emergency load requirements to be fed from the referred Transformers/DG Sets.
- WAPDA Standards/Specifications shall be followed for finalization of the basic design parameters of the electrical equipment/material.
- Technical specifications of the electrical equipment/material shall be prepared at the detailed design stage clearly indicating following parameters:
- Supplier details w.r.t their in house testing procedures, machinery/ skilled staff, testing equipment/tools to ensure after sales services support.
- Warranty/guarantee procedures/requirements to ensure maintenance/trouble free operation of the equipment and system thereof.
- Manufacturing standards of the material/equipment to check the compliance of the product as per applicable international standards.
- Operation & Maintenance setup of the manufacturer/supplier in the vicinity of the project for smooth operation of the system.
- Valid authorizations of the manufacturers (outside the country) for the local suppliers for warranty claims and to establish genuineness of the product.
- Factory Acceptance Tests (FATs) and Site Acceptance Tests (SATs) details to confirm/verify the delivered material in line with the project requirements.
- Requisite applicable type/routine test reports/certificates to check tested values/results in line with the parameters declared in the brochures/technical data of the equipment/material.
- Payment terms /measurements of the installed/delivered material.
- Ratings/sizing of the electrical components/equipment/material like Transformers, DG Sets, cables, Switchgear components, light fixtures, switches, sockets, wiring, conduits/pipes and all allied/associated accessories shall be finalized at detailed designing stage.
- In addition to the recommended lux levels, other lighting requirements like uniformities, Glares etc. shall also be defined for the particular areas/rooms/buildings.
- In various areas fluorescent and High Pressure Sodium Vapour Light fixtures/lamps are mentioned. Keeping in view the energy efficiency aspects (low wattage & higher efficacy) LED indoor as well as outdoor light fixtures shall be proposed for the subject project.

- Separate earthing arrangements shall be made for metallic parts of the equipment/structure and the Circuit Protective Conductor (CPC).
- Costs of the electrical works cannot be reviewed as quantities/ratings of the electrical equipment/material are not available at this stage.
- Complete architectural plans of the colony/ buildings including external areas shall be required from EPC contractor for detail design review.

12.5 REVIEW OF SCADA AND TELECOM STUDIES

12.5.1 Functional Overview / Scope of Work

The following to be included in the SCADA and Telecommunication system hall.

- An In-plant Instrumentation and Control system allowing monitoring and control of the plant (referred hereafter as the station) including generators, all auxiliaries, the associated switchgear, and 132 kV switchyard.
- Establishment of end-to-end digital power line carrier (DPLC) and protection signaling links.
- Installation of Power line coupling equipment for coupling the DPLC equipment to the overhead transmission lines.
- Main Distribution Frame (MDF) for interconnection of PAX to DPLC and DAM/CC/ ADM equipment for speech communication.
- Establishment of duplicated data communication links between Attabad switchyard and NPCC Islamabad.
- Establish complete fiber optic & digital protection signaling links using OPGW to be supplied.
- Operational telephone exchange (PAX) system at Attabad S/S including interconnecting and interface equipment required at Attabad S/S and the peripheral substations for complete integration with NTDC telephone network provided for NPCC.
- SCADA system for remote monitoring and control of Attabad switchyard from NPCC. Database modification and augmentation in mimic display at NPCC.
- Interconnection of SCADA Data Gateway (SDG), telephone PAX and protection relays to the DPLC and optical fiber equipment for communication over DPLC and Fiber Optic links.
- Establishment of two data links from Attabad Substation to NPCC Islamabad on physically separate routes. Scope includes the works to be done at the intermediate substations.
- 48V DC power system at Attabad S/S for powering the equipment.
- Extension and interconnection with the existing PAXs at peripheral substations.
- Site Survey by the Contractor of the existing facilities to determine required interface works and submittal of the Site Survey Report within four weeks of Contract Award. The Survey Report shall be comprehensive and provide detailed information of existing facilities.

- Engineering, design and supply of any devices required for proper interface and working of fully functional telecommunication and SCADA systems even if not specifically mentioned in Scope of Work/Price Schedules.

- Co-ordination with other contractor(s) shall also be deemed to be included in Contractor's scope of work.

12.5.2 Station Instrumentation and Control (I&C) System

This section covers the design, supply, installation, testing and commissioning of Monitoring and Control system (MCS) for 132 kV Attabad substation. Monitoring & Control system for 132kV substation shall include control, monitoring, fault recording, events recording and supervision functions complete with equipment interfaces for the entire substation including but not limited to following.

- Control of substation equipment including circuit breakers, disconnectors and earthing switches to be included.
- Interfacing with protection relays to be included.
- Measurements of voltages, currents, frequency, watts, and VARs through transducers.
- Measurement of status indications.
- Alarm annunciations.
- Interfacing with station voltage regulation equipment for indication and control.
- Event logging and fault recording functions based on inputs from relays and other substation devices/equipment.

12.5.3 Recommendations

1. As per Clause 12.19.4, two alternatives have been discussed for SCADA / Tele-Control by NPCC. Please be noted that as per NTDC's latest requirement all new substations / powerhouses shall be connected via Gateway instead of Remote Terminal Unit (RTU). Therefore, it is recommended to connect the powerhouse/ switchyard (SCADA) via Gateway as discussed in Alternative-2.

2. As per Clause 12.19.8, it has been stated that, "The equipment for teleprotection will have the flexibility for transmission over any communication medium i.e. PLC or OPGW." Please note that, the equipment related to Fiber Optic System (SDH, PDH, AFOC, ODF etc.) is missing in the feasibility report. It is recommended to include complete details of the Fiber Optic System equipment.

3. As per Clause 12.19.9, it is stated that, the Public Address system shall be required at powerhouse only. It is recommended to install the PAS system in 132kV Switchyard & Residential camp also.

4. As per Clause 12.19.12 wherein it is stated that, CCTV system shall be required for the powerhouse. It is recommended to install the CCTV system at switchyard, residential camp & complete powerhouse for the fool-proof security.

5. It is recommended to provide internet & TV Services (Triple Services including Telephone) for the residential camp.

6. Please note that it is recommended to install a separate Telephone exchange (PABX/PAX) for the powerhouse & switchyard.

7. As per Clause 12.19.7.3, it is stated that, “The control room will be additionally connected to the public telephone system to guarantee the communication with the power plant in case of failure of the PLC system”. It is recommended an additional public telephone system (external connection) for powerhouse, switchyard & residential camp. It is recommended to provide public telephone system for the external communication.

8. It is recommended to provide a separate LAN within Powerhouse, switchyard & residential camp.

13 REVIEW OF TRANSMISSION LINE STUDY

Transmission line studies for Attabad Hydropower project carried out at Feasibility stage have been reviewed and following are the review findings.

13.1 TRANSMISSION LINES FROM ATTABAD LAKE HPP

The capacity of the double circuit transmission line is sufficient for evacuation of the 54 MW power of the proposed ALHPP and future generation of power.

In order to meet 'N-1' reliability criteria, double circuit 70km transmission line will also be necessary because in case of contingency outage of one circuit, the complete power will be lost. The option of single circuit is also otherwise not feasible because system voltage and stability will remain at stake even under normal operating conditions, if full capacity of about 130 MW on single circuit line at (40° C min. at wind vel. Of 0 m/s with Current carrying capacity of 626 Amperes for Rail conductor considering Power factor as 0.9.at 132 kV) is utilized with future local generation.

Hence keeping in view the 'N-1' contingency criterion as well as possibility of induction of additional power from future power projects in the area, double circuit transmission line is also recommended up to the existing 33Kv Grid station at Sost.

However, keeping in view the need of Power in current scenario, 132kV Single Circuit Transmission Line is sufficient to fulfill the Power requirements. Therefore, the scope of 132kV Single Circuit T/Line to Sost Grid has been considered in the EPC Contract.

13.2 TYPE OF TOWERS AND BASIC DATA

ZM family of towers are recommend to be used only for the 132Kv transmission line to be constructed in normal terrain. Because of steep gorges area and uncertainty of length of different spans at this stage when no detailed survey has been carried out, and the route may involve crossing of valleys, rivers etc., it would become very difficult to manage to construct the line with ZM type towers, rather we expect to install heavier towers of 220Kv on most of the locations. It is therefore recommended to use mix of 220Kv towers EA, EG & JKD types with few ZM type tower locations especially when ACSR Rail conductor is used. These 220Kv towers would also help covering long spans while maintaining the required strength of the line. Accordingly the cost estimate of the line should also be revised..

The Deflection Angle of ZM-1 mentioned as 30° is a typographical error.

The deflection Angle is **0-2°** for ZM-1 Type Tower.

13.3 INSULATORS

Normally 80KN insulators are used in case of LYNX conductor. For Rail conductor 100 KN insulators are recommended in suspension and 120 KN in Tension assemblies because of long spans in crossings and abnormal/steep hilly terrain. Also to cater for ice loading , after study, we might require to increase the length of strings that would necessitate to use 220kV towers. Additional quantity of insulators as such required for these lines should also be valued in the cost estimate.

13.4 LOAD FLOW STUDIES

The evacuation of power generated at Attabad Lake HPP, is proposed through a 27km, 132kV double circuit of Rail conductor, from ALHPP to the existing (to be upgraded to 132/66/11 kV) Aliabad Grid station and further disperse the power in the Regional Grid Network (RGN).

Along with double circuit 132 kV transmission line to Aliabad, a 132 kV single circuit, with Rail Conductor, of 70 km transmission line is also proposed up to the existing 33kV grid station Sost which is already in operation to cater for the domestic electricity demand and likely to be upgraded to 132/33/11 kV grid station.

Review of the proposed Power Evacuation scheme has revealed that the proposed Double circuit of Rail Conductor at 132kV from ALHPP to Aliabad Grid Station would capable of evacuation of the power generated at ALHPP and upcoming Power Projects in the area, in addition to satisfying the N-1 criterion, as Rail Conductor can carry 20MVA power.

Presently Gilgit-Baltistan area grid of 140 MW capacities is operating in many islands and is not connected to any grid system. Presently the power network is based on Off-Grid and the aim of the project is to bring them on On-Grid in the region and readiness for further connection to the National Grid.

Because of non-availability of Data of any Regional Grid Network and it's inter connection with National Grid, Load Flow Studies cannot be performed at this stage. However Load flow Studies should in added in the EPC scope, which should be performed prior to the COD of the Project.

14 REVIEW OF PROJECT QUANTITIES AND COST ESTIMATES

14.1 GENERAL

Project Quantities and Cost Estimate studies are under Chapter 14: Project Quantities and Cost Estimates of Volume-1: Main Report of the Feasibility study 2021. It presents the estimation of quantities for Attabad Lake Hydropower Project on the basis of feasibility drawings. Following are the review findings for quantity and cost estimation of various works of the project.

14.1.1 Rate Assumption

Escalation allowance by EPC shall be taken care of while quoting the rates for material, manpower and equipment as feasibility rates are based on WAPDA CSR of March 2021.

14.1.2 Price Index

For Local & Foreign cost component the rate of 1 US$. EPC shall consider the actual conversion rate of local currency rate at the time of bidding while quoting his rates.

14.1.3 Development of Unit Rates

Review of Unit Rate development for Labor Cost and Material cost during the course of Feasibility studies is given hereunder.

Labor Cost

The rates of wages for the skilled, un-skilled and operators for various construction equipment are based on market wages in Hunza District of March 2021 shall be considered by EPC at the time of bidding.

Material Cost

The material cost considered in the feasibility study is based on the prevailing rates of March 2021 which shall be adjusted as per the material cost at the time of bidding by EPC Contractor.

14.1.4 Rate Analysis

The rate analysis was worked out for FSR by assuming that,

- Work will be carried out for 8 hours per day and
- 26 working days per month

The EPC Contractor will work at site as per his planning which may exceed to round the clock working in two shifts and work throughout the month during summer season keeping in view the Project construction timelines.

14.2 QUANTITY AND COST ESTIMATE OF MAIN WEIR AND FLUSHING SECTION

The estimated cost for the construction of Main Weir as per MC modified Alternative-I A proposal will be on much lower side as mentioned in Feasibility study for which needs to be confirmed by EPC Contractor after finalizing detail design.

The estimated cost for the construction of sediment flushing section as per MC modified Alternative-I A proposal for the construction of flushing tunnel will be quite on lower side as mentioned in Feasibility study for which needs to be confirmed by EPC Contractor after finalizing detail design.

14.3 QUANTITY AND COST ESTIMATE OF GEOTECHNICAL WORKS

Table 14-2 (Feasibility Report Volume 1) shows that the quantity of excavation at Main Weir, Cofferdams and in under sluices is 92.78% of total excavation. This aspect is illustrated in Table 14.1.

Table 14.1 Review of Quantity Estimates for Excavation Works

Description	Reported Quantities	Proportion of work
Project Excavations	**cum**	**%**
Main Weir	1,008,000	38.87
Under Sluices	1,400,000	53.98
Power Intake, Low Pressure Headrace Tunnel, Surge Tank and Penstock	98,160	3.78
Powerhouse and Tailrace Channel	87,044	3.35
TOTAL	**2,593,204**	**100**

The accuracy of the excavation estimates is unlikely due to availability of cross-sections 50 m apart. Furthermore, disturbance of slided mass can result in further sliding which may increase the quantity of excavation.

The main risks for the increase in estimated cost for the proposed alternative from geotechnical point of view are listed below.

a. The increase in the cost of soil improvement to be applied under the project components.

b. The risk of increase in excavation volumes in the weir location. Especially on the right bank.

c. The risk of slopewash movement in the neighbourhood of powerhouse triggered by the construction activities.

14.4 QUANTITY AND COST ESTIMATE OF HYDROMECHANICAL WORKS

- Steel penstock per ton. Cost mentioned in the table 14-11 of Feasibility report is on lower side and need to be increased.

- Review Comments on hydro-mechanical equipment cost given in Table-14-14 of Feasibility report are given below.
  i. Cost of hydraulic steel structures is on lower side and need to be increased,
  ii. Cost of power intake stoplogs is missing which need to be included,
  iii. Cost of weir gates and stoplogs is missing which need to be included.

- Review Comments on hydro-mechanical equipment cost given in Table-14-15 of Feasibility report are given below.
  i. Cost of hydro-mechanical equipment is a bit on lower side and need to be increased,
  ii. Workshop equipment cost is considerably low and need to be increased,
  iii. Cost of spare parts and erection & testing equipment and maintenance tools is missing which need to be included,
  iv. Cost of two (02) powerhouse elevators is considered whereas its quantity mentioned in the clause 11.14.18 is one (1). It needs correction.

14.5 QUANTITY AND COST ESTIMATE OF TRANSMISSION LINE WORKS

- It is recommended that instead of cost estimates made on some thumb rule, the detailed survey should be carried out at the earliest well before the Tender of the project for EPC contract is floated, and the quantities closer to the actual requirement should be given in the BOQ.
- More time will be required for carrying out the detailed survey due to difficult mountainous area.
- It will reduce the time period of the EPC contract.
- Proper BOQ and Cost Estimate of the Transmission line could be prepared after detailed survey, however a tentative Cost Estimate could be prepared on estimated quantities.
- It is also advisable that as soon as the detailed survey of line is completed, soil investigations should also be arranged to determine the type of foundation required and estimate the cost involved in closer margin.

14.6 QUANTITY AND COST ESTIMATE OF PENSTOCK

The length of steel Penstock will be shortened due to relocation of Powerhouse as per MC alternative proposal, hence the estimated cost for the construction of steel Penstock will be reduced as mentioned in the Feasibility Study for which needs to be confirmed by EPC after finalizing detail design.

14.7 QUANTITY AND COST ESTIMATE OF POWERHOUSE AND TAILRACE CHANNEL

The length of the Tailrace Channel will be increased due to the relocation of Powerhouse as per MC proposal, hence the cost for construction of Tailrace Channel will be increased to some extent as mentioned in the Feasibility Study for which needs to be confirmed by EPC after finalizing detail design.

14.8 REVIEW OF ANNEXURE A EQUIPMENT, MATERIAL AND LABOUR RATES

The cost of construction Equipment, cost of construction material and labour rates listed in this Annexure are on lower side and EPC contractor has to evaluate these costing as per his requirement as per the prevailing market rates for these resources.

14.9 COMPARISON OF QUANTITIES FOR FEASIBILITY STUDY AND REVIEW STAGE STUDY

A tentative comparison has been done for quantities of the Project components from Feasibility stage selected layout “Alternate-I A” and Review stage layout “Modified Alternate-I A”. Details of Feasibility stage layout and Review stage layout are described in chapter 7 of this report. Quantities comparison is given in Table 14.2 through Table 14.7.

Table 14.2 Comparison of Quantities for Rigid Weir and Flexible Overflow Structure

Sr. No.	Description	Units	Quantity		Remarks
			Feasibility Stage	Feasibility Review Stage	
1	Excavation for weir upto design depth in Medium Hard Soil i/c removing of material from outside of the structure area	m^3	828,000	7,595	Drastic reduction in quantities is due to the replacement of the concrete weir structure with the proposed flexible/rigid overflow structure (Gabion mattress) at the feasibility review stage.
2	Excavation for Main Weir upto design depth in Rock Material requiring blasting i/c from outside of the structure area	m^3	180,000	0	
3	Free Draining Backfill	m^3	8,280	0	
4	Lean Concrete 1:4:8	m^3	990	226	
5	Grout Curtain as per design alignment and depth in drawing, size (0.10m x 10m) Approx.	Lm	0	2,000	
6	RCC 1:1.5:3 for core using crushed stone aggregate (screening & ashing) and coarse sand i/c cost of all labor and material and all kinds of form works, molds, shuttering lifting/pumping, curing, rendering and finishing the exposed surface excluding steel reinforcement	m^3	10,920	365	
7	Reinforcement Grade 60 in Lining	Ton	655.2	0	
8	Gabion Complete in all respects	m^3	0	7,024	Quantity of gabions added as proposed at the feasibility review stage.
9	Dewatering	LS	1	1	
10	Riprap Protection	m^3	2,160	0	Items will not be utilized for the proposed Alternative 1A.
11	Protection with Gabions	m^3	1,000	0	
12	Miscellaneous 5% for joints of all types, Drainage, Architectural details, finishes etc.	LS	1	1	

Table 14.3 Comparison of Quantities for Under sluices and Flushing Tunnel

Sr. No	Description	Units	Quantity		Remarks
			Feasibility Stage	Feasibility Review Stage	
1	Clearing and Grubbing of area 300m upstream of the weir	m^2	10,875	0	Flushing Tunnel was not part of the feasibility stage, added later in review feasibility stage.
2	Excavation for Flushing Tunnel/Under sluices upto design depth in Medium Hard Rock requiring blasting i/c removing of material from outside of the structure area	m^3	280,000	25,423	
3	Compacted Concrete	m^3	413	0	
4	Riprap face protection u/s	m^3	500	0	
5	PCC in overbreak section including placing, compacting, finishing & curing (Ratio 1:2:4)	m^3	0	1,518	
6	Lean Concrete 1:4:8	m^3	645	226	
7	Shotcrete excluding wire mesh reinforcement	m^3	0	1,477	
8	Providing and fixing wire mesh as per drawing (6mm dia., 15x15 cm)	m^2	0	11,416	
9	Providing and fixing wire mesh as per drawing (8mm dia., 10x10 cm)	m^2	0	8,585	
10	RCC 1:1.5:3 for Lining / Under sluices using crushed stone aggregate (screening & ashing) and coarse sand i/c cost of all labor and material and all kinds of form works, molds, shuttering lifting/pumping, curing, rendering, and finishing the exposed surface excluding steel reinforcement	m^3	9,970	13,111	
11	Reinforcement Grade 60 in Lining / Under sluices	Ton	499	524	
12	Rock Bolts 3m long and 26mm dia. including grouting complete in all respects	No.	0	6,829	
13	Advance early strength rock bolt 4 m long complete in all respects as per drawing	No.	0	448	
14	Steel Rib NPI 180	Lm	0	4,821	

Sr. No	Description	Units	Quantity		Remarks
			Feasibility Stage	Feasibility Review Stage	
15	Excavation for upto design depth in Medium Hard Soil removing of material from outside of the structure area	m^3	1,120,000	3,018,903	
16	Back Filling	m^3	0	204,000	
17	Adits (Access Tunnel)	LS	0	1	
18	Grout Curtain	LS	1	0	
19	Dewatering	LS	1	1	
20	Consolidation Grouting	LS	1	0	
21	Miscellaneous 5% for joints of all types, Drainage, Architectural details, finishes etc.	LS	1	1	

Table 14.4 Comparison of Quantities for Power Tunnel

Sr. No	Description	Units	Quantity		Remarks
			Feasibility Stage	Feasibility Review Stage	
1	Excavation for Headrace Tunnel upto design depth in Medium Hard Rock requiring blasting i/c removing of material from outside of the structure area	m^3	60,737	71,085	
2	PCC in overbreak section including placing, compacting, finishing & curing (Ratio 1:2:4)	m^3	4,191	0	
3	Lean Concrete 1:4:8	m^3	1,030	1,074	
4	Shotcrete 35mm thick-fiber reinforced	m^3	1,012	0	35mm thick-fiber reinforced shotcrete in the feasibility stage is replaced with shotcrete excluding wire mesh and wire mesh (6mm dia., 15x15 cm) and (8mm dia., 10x10 cm) at the

Sr. No	Description	Units	Quantity		Remarks
			Feasibility Stage	Feasibility Review Stage	
					feasibility review stage.
5	Shotcrete excluding wire mesh reinforced	m^3	0	4,430	Added at Feasibility review stage as tentative design of tunnel support system.
6	Providing and fixing wire mesh as per drawing (6mm dia, 15x15 cm)	m^2	0	24,755	
7	Providing and fixing wire mesh as per drawing (8mm dia, 10x10 cm)	m^2	0	32,270	
8	RCC 1:1.5:3 for Lining using crushed stone aggregate (screening & ashing) and coarse sand i/c cost of all labor and material and all kinds of form works, molds, shuttering lifting/pumping, curing, rendering and finishing the exposed surface excluding steel reinforcement	m^3	9,935	10,602	
9	Reinforcement Grade 60 in Lining	Ton	397	424	
10	Rock Bolts 4m long with 4m spacing	Ton	1,728	0	4m long rock bolts in the feasibility stage are replaced with Advanced early strength 4m long bolts and 2.6m long rock bolts with 26m diameter in the feasibility review stage.
11	Rock Bolts 2.6 m long and 26mm dia. including grouting complete in all respects	No.	0	1,686	Added at Feasibility review stage as tentative design of tunnel support system.
12	Advance early strength rock bolt 4 m long complete in all respects as per drawing	No.	0	196	
13	Steel Rib NPI 180	Lm	0	17,662	
14	Adits (Access Tunnel)	LS	1	1	

Sr. No	Description	Units	Quantity		Remarks
			Feasibility Stage	Feasibility Review Stage	
15	Dewatering	LS	1	1	
16	Miscellaneous 5% for joints of all types, Drainage, Architectural details, finishes etc.	LS	1	1	

Table 14.5 Comparison of Quantities for Penstock

Sr. No	Description	Units	Quantity		Remarks
			Feasibility Stage	Feasibility Review Stage	
1	Excavation for Penstock upto design depth in Medium Hard Rock requiring blasting i/c removing of material from outside of the structure area	m^3	1,382	2,928	Due to the relocation of the powerhouse at the feasibility review stage, the length of the penstock has decreased. However, the cut volumes have increased due to the adjustment of the penstock longitudinal profile according to the new powerhouse location.
2	Excavation for Penstock upto design depth in Medium Hard Soil removing of material from outside of the structure area	m^3	15,600	26,349	
3	PCC in overbreak section including placing, compacting, finishing & curing (Ratio 1:2:4)	m^3	110	110	No Change
4	Shotcrete 35mm thick-fiber reinforced	m^3	51	51	No Change
5	Filter Material	m^3	1,400	933	Due to the relocation of the powerhouse at the feasibility review stage, the length of the penstock has decreased. Hence, the quantities have decreased.
6	RCC 1:1.5:3 for Lining using crushed stone aggregate (screening & ashing) and coarse sand i/c cost of all labour and material and all kinds of form works, moulds, shuttering lifting / pumping, curing, rendering and finishing the exposed	m^3	1,354	948	

Sr. No	Description	Units	Quantity		Remarks
			Feasibility Stage	Feasibility Review Stage	
	surface excluding steel reinforcement				
7	Reinforcement Grade 60 in Lining	Ton	81	54	
8	Rock Bolts 3m long with 2m spacing	No	123	123	No Change
9	Dewatering	LS	1	1	
10	Miscellaneous 10% for joints of all types, Drainage, Grouting, finishes etc.	LS	1	1	
11	Penstock	Ton	802	535	Due to the relocation of the powerhouse at the feasibility review stage, the length of the penstock has decreased. Hence, the quantity has decreased.

Table 14.6 Comparison of Quantities for Powerhouse

Sr. No	Description	Units	Quantity		Remarks
			Feasibility Stage	Feasibility Review Stage	
1	Excavation for Powerhouse upto design depth in Medium Hard Soil removing of material from outside of the structure area	m^3	74,451	138,318	The power has been relocated to a more suitable location at the feasibility review stage, resulting in change of excavation and backfill volumes.
2	Backfilling	m^3	74,451	52,000	
3	Lean Concrete 1:4:8	m^3	635	635	No Change
4	RCC for Sub structures and around Draft Tubes using crushed stone aggregate (screening & ashing) and coarse sand i/c cost of all labor and material and all kinds of form works, molds, shuttering lifting/pumping, curing, rendering and finishing the exposed surface excluding steel reinforcement	m^3	7,774	7,774	
5	RCC 1:1.5:3 for walls, columns, slabs and floors using crushed stone aggregate (screening & ashing) and coarse sand i/c cost of all labor and material and all kinds of form works, molds, shuttering lifting/pumping, curing, rendering and finishing the exposed surface excluding steel reinforcement	m^3	3,426	3,426	
6	Reinforcement Grade 60	Ton	715.45	715	
7	Dewatering	LS	1	1	
8	Miscellaneous 15% for joints of all types, Drainage, Architectural details, and finishes, etc.	LS	1	1	

Table 14.7 Comparison of Quantities for Tailrace Channel

Sr. No	Description	Units	Quantity		Remarks
			Feasibility Stage	Feasibility Review Stage	
1	Excavation for Tailrace Channel upto design depth in Medium Hard Soil removing of material from outside of the structure area	m^3	12,593	75,558	Due to the relocation of the powerhouse at the feasibility review stage, the length of the tailrace channel has increased. Hence, quantities have increased correspondingly.
2	RCC 1:1.5:3 for Lining using crushed stone aggregate (screening & ashing) and coarse sand i/c cost of all labour and material and all kinds of form works, moulds, shuttering lifting / pumping, curing, rendering and finishing the exposed surface excluding steel reinforcement	m^3	1,750	10,500	
3	Reinforcement Grade 60	m^3	105	630	
4	Backfill	m^3	1,440	8,640	
5	Dewatering	LS	1	1	No Change
6	Miscellaneous 10% for joints of all types, Drainage, Grouting, finishes etc.	LS	1	1	

15 REVIEW OF CONSTRUCTION PLANNING AND COST ESTIMATES

15.1 FACTORS AFFECTING PROGRESS OF CONSTRUCTION WORKS

The EPC Contractor shall plan the construction schedule keeping in view the non-productive periods of project especially two months severe winter season when the ambient temperature is below freezing point at site and the construction materials storage shall also be ensured properly protected from severe cold weather.

15.2 PROCUREMENT AND STORAGE OF MATERIALS

15.2.1 Cement

The EPC shall consider the provision of weather proof Cement silos for feeding of concrete batching plants round the year without the intrusion of moisture and will also consider the shelf life of Cement. The source approval for Cement will be subjected to the compliance of relevant standards of ASTM C-150. For mass concrete in project, use of pozzolonic material with the cementious material will also be subjected to the results of Aggregates having ASR value (Alkali Silica Resistance) or having heat of hydration more than specified limits.

15.2.2 Coarse Aggregate

Coarse Aggregates sources of Passu and Powerhouse area will be used for concrete production. The marble present in Passu area and Rounded Boulder Gravel Silt (RBGM) at Powerhouse Area can be used as coarse aggregate by certain amount of processing, i.e. crushing, washing, screening and blending. The suitability of coarse aggregate will be subjected to the complying the requirements of relevant ASTM Standards.

15.2.3 Fine Aggregate (Sand)

Huge quantity of shiskat sand deposits downstream of Attabad Lake can be checked by the EPC for the production of concrete for the project. The suitability of fine aggregate will be finalized on complying of the sand with the relevant standards of ASTM.

15.2.4 Reinforcing Steel

The reinforcing steel G-60 or reinforcing steel G-40 will be approved on the source selection and the complying of reinforcing steel with relevant standards of ASTM. Proper reinforcing Steel yard is required to be developed by EPC Contractor with sufficient stock of material to match with the pace of site work.

15.2.5 Explosive Materials

Sufficient Explosive Material will be required at site for drilling & blasting of hard rock strata and shall be utilized within its expiry date.

15.2.6 Steel Plates and Steel Formwork

The steel plates and steel formwork to be used for embedment and for concrete works shall be of good quality complying with the requirements of their relevant international standard.

15.2.7 Water and Stone for Riprap and Fill Material

The water to be used for construction and drinking purpose shall be potable and fit for drinking along with the complying of relevant health standards. Rip Rap stone to be used for protection works of structure shall be complying with the requirements of hydraulic design and relevant

test standards. The fill materials to be used for different structures shall be selected as per the requirement and complying with the relevant standards.

15.3 REVIEW OF CONSTRUCTION PLANNING AND METHODOLOGY

The key for the timely completion of the Project is the construction of low-pressure Headrace Tunnel whose length is 2.3 km and this activity is on critical path which EPC contractor has to consider during preparation of Project Execution Schedule and arrange the resources accordingly

15.3.1 Care and Handling of Water

The two temporary coffer dams were proposed to be constructed as per Feasibility Report. First coffer dam on upstream of sediment flushing channel / under sluice and second on upstream of overflow weir. The alternative proposal by MC mentioned in Chapter 7 for construction of sediment flushing tunnel underneath the Power Intake in lieu of sediment flushing channel / under sluice will be carried out together through adit from downstream and the rock ridge on upstream will act as coffer dam for their construction and this rock ridge will be drill and blast after completion of construction whereas the placement of stepped flexible Gabion Mattress on existing weir crest will be carried out during low flow season.

EPC Contractor needs to submit the Method Statement for Care and Handling of Water for finally selected layout during detail design studies along with the detail design of coffer dam (if any) and dewatering scheme for a safe working area.

15.3.2 Sediment Flushing Tunnel / Channel (Under sluice)

The excavated material of sediment flushing tunnel / Channel (under sluice) will be disposed-off at spoil areas planned near the Powerhouse site as the spoil area designated shall have sufficient area to accommodate the surplus excavated material. The construction of sediment flushing Tunnel / channel (Under Sluice) is envisaged to be completed in 8 months period depending upon the available resources at site.

Upon the completion of sediment flushing tunnel underneath the Power Intake, lake water will be diverted through this structure, to commence construction activities on power intake and overflow weir section and will act as diversion tunnel.

15.3.3 Power Intake

The excavation and concreting activities at power intake structure are envisaged to be completed in 12 months period. After the completion of power intake structure, a trash rack cleaning machine (TRCM) will be installed for removal of debris in front of trash racks. A gantry crane will be installed for placement and removal of the stoplogs designed on the basis of their weights.

15.3.4 Overflow Weir / Ungated Spillway

The stone apron will be provided at the upstream and downstream side for overflow weir having stepped flexible Gabion Mattress on top of existing crest level for weir. Before placing stone apron and Gabion Mattress, the ground will be properly adjusted and compacted and if required covered by a filter fabric. The overflow weir is envisaged to be completed in 6-month period. Upon completion of overflow weir, the working area will be re-flooded to match the lake water level.

15.3.5 Access Tunnels / Adits for Headrace Tunnel

The excavation of these two access tunnels for headrace tunnel one on the Power Intake side and the other is on the surge tank side will be done using the drill and blast technique which will also be used for the low-pressure headrace tunnel.

15.3.6 Low Pressure Headrace Tunnel

After the completion of construction activities of low-Pressure headrace tunnel, the access tunnels / adits will be plugged on both sides with the concrete mix of special type. Total time of construction around 25 months has been estimated for the excavation, rock support measures and concrete lining of low-pressure headrace tunnel

15.3.7 Surge Tank

After completion of excavation, the concrete lining in this structure will be taken up immediately by starting from its bottom to top with slip forms moving in an upward direction towards the tank collar. A total of 12 months has been allocated for completion of the underground excavation and concrete works of the surge tank.

15.3.8 Penstock

The total time for construction of Penstock (Steel lined portion & concrete Portion) starting from surge shaft to Powerhouse is estimated to be 10 months depends upon the availability of steel plate complying with the relevant standard used for fabrication of steel liner.

15.3.9 Powerhouse Civil Works

All these activities related to powerhouse construction will be completed in 15.5 months. The Powerhouse architectural works will be completed parallel to testing and commissioning of units as the architectural finishes items to be used for Powerhouse shall comply with the relevant standards.

15.3.10 Unit Erection

A proper coordination will be required between Civil & Mechanical EPC Contractor's site teams for unit erection works in Powerhouse which will ensure timely completion of the Project.

15.3.11 Mechanical & Electrical Installations

The total time for excavation, concreting of foundations in Powerhouse and installation of vertical Francis turbines, generators, transformers and auxiliary systems is estimated to be 21 months which require timely placement of order for manufacturing to the approved vendors, custom clearance from Port and uninterrupted transportation of Equipment to site.

15.3.12 Tailrace Channel

The detail design of tailrace channel shall be carried out in such a manner that the flow will smoothly discharge into Hunza river from turbine draft tubes of turbines keeping all the hydraulic parameters within the permissible limits.

15.3.13 Switchyard

The construction of control building is also required along with the construction of 132 kV Switchyard where Power and Control Panels for switching of different bays will be carried out. All the Power and Control cables through cable trenches will terminate in these panels.

15.3.14 Transmission Lines

Two transmission lines, one from Attabad switchyard to Aliabad grid station (double circuit approx. 27km) and other from Attabad switchyard to Sost grid station (single circuit approx. 70km) shall be constructed. The total construction period for both transmission lines of 23 months will be achieved subjected to the approval of detail design, route survey and availability of construction materials.

15.3.15 Assembly of Electro-Mechanical Equipment

The transportation of heavy Electro-Mechanical Equipment shall be planned by EPC in such a way that the equipment shall arrive at site with the foundation ready to receive the equipment directly on it to avoid protection from wear and tear.

15.3.16 Testing and Commissioning

The two months duration for the final testing and commissioning shall be planned by EPC in such a manner that the design flow required to guarantee the full installed generation capacity of the Project.

15.4 REVIEW OF PROJECT IMPLEMENTATION SCHEDULE

During detailed design and execution of actual works, EPC Contractor may develop his own construction schedule in such a way that most of the works can be taken up simultaneously as per the resource allocation on various project components in order to complete the project in the shortest possible time. The requirement of coffer dam construction can be assessed by EPC on the basis of methodology used for the construction of sediment flushing tunnel underneath the Power Intake and placement of stepped Gabion Mattress on existing weir crest.

15.5 CONSTRUCTION MANAGEMENT

15.5.1 Project Executing Agency

WAPDA as Project Execution Agency will also coordinate with Gilgit Baltistan's authorities and departments for any issues arising about the project execution, which require resolution by inter-departmental interaction for smooth Project execution.

15.5.2 Consultants

During the Construction Phase of the Project, the Consultants will in general review & monitor the detailed design, construction procedures, Inspection & Testing Plans, Quality assurance & Quality Control Manual, manufacturing, procurement, installation, commissioning & testing of works by the EPC Contractor. The Consultant's services will be in close coordination with the Project Executing Agency WAPDA.

16 REVIEW OF ENVIRONMENTAL IMPACT STUDY

16.1 GENERAL

The Volume 6 of Feasibility study 2021 represents the Environmental and Socioeconomic Impact Assessment (ESIA) Report. WAPDA has submitted the ESIA Report to Gilgit Baltistan Environmental Protection Agency (GBEPA) in August 31, 2022 to initiate the process of No Objection Certificate (NOC) / Environmental Approval. The title of document should be Environmental Impact Assessment (EIA) or Initial Environmental Examination (IEE) as per regulations being followed by Gilgit Baltistan Environmental Protection Agency (GBEPA), not an Environmental and Socioeconomic Impact Assessment (ESIA). Moreover, an executive summary should be included in the document.

Following are the section/chapter wise review findings and comments for Volume 6 of the Feasibility report.

16.2 CHAPTER 1: INTRODUCTION

1. Please refer to ***Section 1.3: Environmental and Social Impact Assessment (ESIA)***

- After the 18th Amendment protection of the environment became a provincial subject, so it is better to use Gilgit Baltistan Environmental Protection Act, 2014, instead of Pakistan Environmental Protection Act, 1997.
- Screening had been carried out for EIA while the title of document is ESIA, needs correction.
- Either the proposed project is being funded by World Bank or not, as it referred the World Bank guidelines (OP 4.0).

2. Please refer to ***Section 1.4 Project Categorization***

- Since the proposed project falls under the schedule II requiring an EIA, while the name of document is ESIA, there is no provision of ESIA under IEE/EIA Regulations 2000.
- If the project is not being funded by donor agencies, then there is no need to mention the WB, ADB and JICA, their requirements are more stringent than national/provincial laws in specific aspects.
- As it is mentioned that the proposed project involve installation of 132kV transmission line as well, so the consent of GB EPA was obtained that either a consolidated document/EIA or separate documents/EIAs for hydropower and transmission line will be submitted to GBEPA? Both Hydropower and 132kV Transmission Line may have adverse environmental and social impacts.

3. List of EIA team is not provided. Project Location map showing the location and area of influence needs to be provided to assess/have an idea of environmental and social impacts of the area.

16.3 CHAPTER 2: PROJECT DESCRIPTION

1. Project Alternatives are not provided/discussed, including no project option, based on cost, design, location and other technical aspects considered while designing different components of hydropower and associated transmission lines.
2. Project layout plans are not provided.

3. Limited design details are provided for 132kV Transmission Line, it needs to be elaborated to properly encounter the possible environmental and social risks and impacts.
4. Safety consideration during operation are not provided.
5. Construction planning aspect is also not provided including but not limited to: details of construction camps, work force required during construction and operation phase, water requirements, power requirements, material requirements and source, construction schedule, project cost etc.

16.4 CHAPTER 3: REGULATORY LAWS AND THE INSTITUTIONAL FRAMEWORK

1. GB Environmental Protection Act 2014 is the core act in Gilgit Baltistan dealing with environment related issues, which has not been discussed in the main report.
2. Following, but not limited to, Acts are not considered in the report:

- Prohibition of Employment of Children.
- Gilgit-Baltistan Forest.
- Fisheries
- GB Disaster Management.
- Protection against Harassment of Women at the Workplace.

3. Pakistan is a member/signatory of several international organizations; the report is silent regarding International Treaties and Conventions.
4. Please refer to ***Section 3.4.1 Land Acquisition Act (LAA), 1894***, in addition to LAA, 1894, it is mentioned that the proposed project fulfil the requirements of World Bank, again if the project is not being funded the WB then no need to follow its guidelines, as these are more stringent than LAA, 1894 and may face difficulties while complying.
5. The relevancy of each act may be provided that either it is applicable to the proposed project or not.
6. Guidelines for the preparation of EIA report are not provided such as Guidelines for Public Consultations, Guidelines for Sensitive and Critical Areas and Guidelines for the preparation and review of Environmental reports.

16.5 CHAPTER 4: BASELINE CONDITIONS

1. Overall, the baseline information (physical, biological and socio-economic environment) provided in the report is generic and representing almost whole province (Gilgit Baltistan). The baseline information needs to be revised and should be project specific.
2. Sources of secondary information are not provided, supporting maps of the project area may also be provided.
3. Time period of climatic data is not provided.
4. Either the Environmental Monitoring was carried by EPA certified Laboratory or not?
5. Number of Monitoring points along with location is not discussed, only results of one (01) point of ambient air and noise is provided. Moreover, comparison with NEQS is also not provided.
6. Separate noise values are not provided for daytime and nighttime intervals as per NEQS.
7. Detail regarding the sensitive receptors of the project area are not provided. It may help in actual impact assessment and their mitigation measures.
8. Please refer to ***Section 4.1.10: Land Use***, The land use of project area needs to be provided where the project interventions are proposed instead of whole province (Gilgit Baltistan).
9. Please refer ***Section 4.1.18: Surface Water,*** Environmental Monitoring, Sampling and Testing of water quality is not provided as per NEQS.

10. Please refer to ***Section: 4.2.6 Endangered, Threatened or Vulnerable Species of Fauna***, *the endangered, threatened and vulnerable species in the project area are Markhor (Capra flconeri) Snow leopard (Unica unical) Ladakh urial (Ovis vignei) Woolly flying squirrel (Eupegaurus cinereus.).* It needs to be rechecked, the relevant expert carried the ecological survey or not?
11. Please refer to ***Section 4.3: Social and Economic Environment***, either the socio-economic survey was carried out with the project affected persons or not, as no information about no. of respondents interviewed, their socio-economic conditions, sample size, project acceptability etc. is provided.

Stakeholder Consultations

1. Stakeholder Consultation is an important part of the environmental studies, this chapter is missing in this report.

16.6 CHAPTER 5: ESIA AND MITIGATION MEASURES

1. Please refer to ***Section 5.1: General***, multiple funding agencies have been mentioned in this report, if the proposed project is not being funded by the ADB, then no need to mention that impact assessment has been carried out using checklist developed by ADB.
2. Please refer to ***Section 5.2: Impact Assessment Procedure***, Impact evaluation matrix is not provided.
3. Please refer to ***Section 5.3: Impacts During Construction***, Impacts may be categorized into different phases of project like pre-construction, construction and operation phase for better assessment.
4. Land acquisition is a critical issue, while this impact is not covered in this chapter. Hoverer, in ***Section 6.8: Land Requirements for The Project (Chapter 6)***, it is mentioned that land (government and private) will be acquired for the proposed project.
5. Overall, the impact assessment (physical, ecological and socio-economic environment) is generic keeping in view the extent of project, it needs to be revised based on project activities and quantified. In addition, following impacts but not limited to, are also anticipated due to the proposed interventions which are not addressed: wastewater generation, solid waste management, siting of construction camps, emergency response, land acquisition, labour influx, child and forced labor, COVID-19, gender issues, community health and safety etc.
6. Since the proposed project involves the installation of 132kV Transmission Lines, the present impact assessment is not covering this aspect.
7. In baseline conditions, it is mentioned that in project area there are endangered, threatened and vulnerable species, the impact assessment is silent in lieu of these species.
8. Impact assessment is based on the project specific baseline for the physical, biological and social profile, since the existing Baseline Conditions (***refer chapter 5***) presented for the whole province instead of project specific area. Keeping in view the above, the impact assessment needs substantial improvement.

16.7 CHAPTER 6: ENVIRONMENTAL MANAGEMENT AND MONITORING PLAN

1. Please refer to ***Section 6.2: Mitigation Management Matrix (MMM)***, under this section, a table needs to be provided including impacts, mitigation measures, responsibilities, monitoring frequency, and monitoring indicators etc.
2. Institutional Arrangement for Implementation of EMMP during construction and O&M phases is not provided. Further, roles and responsibilities of implementing agencies is also not provided.

3. Following guidelines, but not limited to (as per advice of Environmental Specialist), need to be provided for the preparation of site specific environmental and health & safety management plans: *Tree Plantation / Reforestation Plan, Health, Safety and Environment (HSE) Management Plan, Emergency Preparedness and Response Plan, Restoration and Rehabilitation Plan, Waste Management Plan, Disaster Management Plan, Drinking Water Supply and Sanitation Plan, Traffic Management Plan, Change Management Plan, Resource Conservation Plan etc.*
4. Please refer to ***Section 6.6: Impact Monitoring Program***, detailed monitoring plan needs to be provided including monitoring parameters, location, monitoring mechanism, frequency, duration etc.
5. Please refer to ***Section 6.9: Environmental Mitigation and Land Acquisition Cost***, Costs related to Land Acquisition, HSE, Environmental Monitoring, Tree Plantation, Environmental, Social & Health and Safety Experts are not provided.
6. This ESIA including EMMP should be made a part of bidding document to ensure the compliance, there a separate section / a paragraph needs to be provided showing the inclusion of ESIA including EMMP into the contract documents.
7. Reporting and Documentation section is also not provided.
8. Trainings and Awareness Plan including type of training, staff/participants, schedule, responsibility etc. also not provided.
9. Appropriate Grievance Redress Mechanism (GRM) is not provided to resolve the complaints.

16.8 CONCLUSIONS AND RECOMMENDATIONS

This chapter is missing in the Feasibility Report.

17 REVIEW OF ECONOMIC AND FINANCIAL ANALYSIS

17.1 GENERAL

The Attabad Hydropower Project will be located on Hunza River. The project is 20 km from Karimabad, 120 km from Gilgit and 735 km from Islamabad. Initial Feasibility of Attabad Lake Hydropower Project (ALHPP) was conducted by Govt. of Gilgit-Baltistan in 2016-17, with the estimated installed capacity of 32.5 MW. In 2019, WAPDA updated the project feasibility study with proposed installed capacity to 54 MW with a 2320 m long headrace low pressure tunnel on the left side of Hunza River. According to Feasibility Report 2019, It will have an installed capacity of 54MW, capable of producing 374 GWh of average annual energy per year. According to the construction schedule provided in the Consultant's Report, the total construction time for ALHPP is about thirty-six (36) months.

This review report briefly discusses the economic and financial analysis of the feasibility report, as prepared by WAPDA in 2019. The financial and economic parameters associated with project benefits and costs were studied and compared with reference to Economic and Financial Analysis (Chapter 17 of Feasibility Study Report) along with the judgment from other similar nature projects.

The objectives of the review were to verify the main parameters, analysis and results of economic and financial analysis of ALHPP and provide review comments, suggestions and recommendations, if any.

Following are the key aspects covered during the study.

i) Review of assumptions and calculation of economic parameters, conversion factors, prices etc.
ii) Review of methodology and parameters adopted for estimation of economic benefits of hydropower.
iii) Review of Economic Internal Rate of Return (EIRR) and sensitivity tests.
iv) Review of assumptions and parameters used for financial analysis.
v) Review of estimation of energy revenues.
vi) Review of composition of total investment cost of the project, including price escalation, interest during construction and cost of project financing.
vii) Review of financial profitability, financial internal rate of return (FIRR) etc.
viii) Review of unit generation cost.
ix) Indication of shortcomings (if any) and suggestions for improvement.

To ascertain the financial and economic viability of the said project, the analysis has been reviewed on the basis of efficiency criterion of public investment using "discounted cash flow" technique. The parameters like "Net Present Worth", "Benefit Cost Ratio", and "Internal Rate of Return" have been reviewed in detail by rechecking calculations.

Following are the main comments/observation on economic and financial analysis of the project.

17.2 REVIEW OF ECONOMIC ANALYSIS

- Opportunity cost of capital/cut-off discount rate has been taken as 12% for deciding the economic viability of the project.
- Standard Conversion Factor (SCF) has been calculated as 0.91 on the basis of data from 214-15 to 2018-19. In some places, the figure of 0.90 was used. The data on total exports, import duty and sales tax on imports (Table-17-6) was not found correct. Once

substantiated with updated data of import/export and tax/subsidies statistics, SCF has been recalculated as 0.871.

- Shadow wage rate for labour has been used as 0.75 in the Feasibility report.
- Economic cost has been estimated as Rs. 18410 Million, using the base cost of Rs. 20028 Million.
- While converting the financial investment cost of ALHPP to economic cost, the taxes have not been deducted from the base cost. Taxes are transfer payments and usually excluded in economic cost.
- Economic appraisal has been undertaken mainly on the basis of conventional avoided costs of equivalent thermal plant. The LNG based thermal power plant (OCGT) was indicated as alternate equivalent thermal power source. The investment cots of alternate thermal power plant has been assumed as USD 1.0 Million (at the given exchange rate of 1USD=157 Pak Rupee), which seems on a higher side. This investment cost has been phased in two years (50% each).
- The installed capacity of equivalent thermal power plant is not mentioned in the document.
- Annual O & M cost of OCGT plant has been assumed as 3% (USD 0.004/kWh), which seems reasonable.
- LNG price (fob) has been taken as USD 7.48 MMBtu. The fuel cost has been calculated as Rs. 8.42 per Kwh. The fuel cost need to be updated as per latest prevailing prices.
- Saving of fuel and O & M cost of alternate thermal power plant has been taken as major economic benefits of ALHPP.
- Emission reduction benefits of ALHPP in economic analysis were calculated on the basis of CDM financial price of USD 1.5 per Ton of CO2, which is not correct. The economic benefits of CO2 emission reduction are based on “Global Social Cost of Carbon” rather than on financial price of CDM.
- The operating cost of hydel station is mentioned as 1% of base cost. The difference of civil and electro-mechanical items has not been adopted.
- EIRR of ALHPP was calculated as 22.54% and 22.36% for with and without emission scenario. Sensitivity analysis showed that EIRR calculated was robust and remained above opportunity cost of capital (12%) even under worst assumption of simultaneous increase in project cost and decease in project benefits.

17.3 REVIEW OF FINANCIAL ANALYSIS

- Project cost has been worked out at price level of 2021, with an exchange rate of 1USD=157 Pak Rs.
- Project base cost has been calculated as Rs. 20028.920 Million, phased in three years.
- Price escalation (during construction) has been estimated as Rs. 1000.537 Million, using annual inflation rate of 6.5% for local cost and 2% for foreign cost.
- Keeping in view the historic increase in US CPI, foreign escalation rate need to be reconsidered.
- Source of financing is not mentioned in the Feasibility study.
- Interest During Construction (IDC) was not calculated, shown as zero.
- Total financial cost (without IDC) was calculated as Rs. 21246 Million.
- While doing the amortization of financial investment cost for calculating the Unit Generation Cost, the interest rates for local and foreign cost financing have been kept same (12.20%), which may be different if there is different sources of financing.
- Unit generation cost has been estimated as Rs. 5.67 per kWh, which seems attractive.

- The energy sale price has been assumed as Rs. 13.40 per kWh for estimating energy sales revenues. If the energy is intended to be sold in GB, this seems higher sale price as the existing tariff rate in GB is lower (under Rs. 10 per kWh).
- Annual energy revenues have been estimated as Rs. 5007 Million while CDM revenues (@ USD 1.5 per Ton) were found as Rs. 29.92 Million.
- FIRR has been estimated as 19.27% and 19.17% for with and without CDM benefits.
- Sensitivity analysis of FIRR has not been performed.
- Payback of investment cost has been estimated as 5 years, however backup calculation is not given.

17.4 RECOMMENDATIONS FOR FURTHER IMPROVEMENT OF STUDIES

Following are the important recommendations for improving the robustness of economic and financial analysis of the said project:

- For economic analysis, taxes and duties need to be exempted from economic cost.
- Energy sale price need to be reconsidered, keeping in view existing tariff in GB.
- A detailed sensitivity study to check the robustness of financial model is required which would ultimately impact the financial viability of the project.
- The financial analysis needs to be updated on the basis of careful and through project cost reviews.

18 CONCLUSIONS AND RECOMMENDATIONS OF REVIEW STUDY

The Dam due to landslide created a Lake behind it at Attabad not only possess a threat but at the same time an opportunity for making use of the head due to this Earthen Dam. Due to lake formation, there is potential drop of more than 100 m in 2.5 km river reach. The mean annual flow of Hunza River at Attabad Lake is 204 m^3/s. The Project Layout is to be configured considering the power demand and demand pattern of regional grid. Attabad Lake storage can be used for daily peaking. A design discharge with peaking storage facility is to be selected to generate the installed capacity 95% time of the year in peak hours. From the available flow data and estimated flow series at Project Area, a discharge of 60 m^3/s has been taken as design discharge for power generation.

A modification in Feasibility stage Alternative- IA layout is proposed by MC based on Feasibility Report review findings and site visit observations. The modifications, as summarized hereunder, are to be checked for technical and economic viability during Detail design stage by EPC Contractor.

If a flushing tunnel is added underneath the intake area at distance of 7m away in the plan and its outlet after the most disturbed area, it will increase the life of Power house for many years. A tentative discharge of about 72 m^3/s for flushing tunnel will be required which is available plenty of time throughout the year. Only risk involved in this concept will be outlet portion of the flushing tunnel which will lie in overburden area. Cut and cover conduit or even open channel can be provided in this overburden area. In worst conditions, if some damage occurs to outlet structure, it can easily be repaired any time because flushing will not be done throughout the year.

Another aspect if in case all past slided mound at Weir site is washed away at weir site, then a temporary coffer dam can be constructed for constructing new/ fresh weir / dam in this area.

In case we move intake structure to weir location and in case all slide material washed away then in this scenario to restore electricity from Power house we have to wait for restoration of weir / dam first then Power house will be in operation condition.

To strengthen the present weir / dam area MC propose a gabion mattress overlay in all area of weir site to avoid long term damages during flood season.

The reduction in the total project excavation by avoiding excavation for abutments and foundation of overflow weir will considerably reduce the overall cost of the project due to presence of slided mass on right and left banks both.

Based on verification study and calculations, the solution finalized in the Feasibility study with installed capacity of 54MW and 79% plant factor is most optimized solution. However, as per recommendations from Mechanical expert, efficiency of turbine can be taken as 93%. MC endorse the selection of turbine with 93% efficiency which may result in little higher installed capacity of about 57 MW.

Based on review of Feasibility Report, MC validate the data and importance to construct the Attabad Lake Project as early as possible.

ALHPP is found to be technically feasible, economically viable and environmentally acceptable and will fulfill electricity needs particularly for Hunza City and in general for Hunza, Gilgit and Ghizar Regions. Therefore, recommended for implementation at the earliest.