

Pumping Station's



Wire to Water

Specific Power (kW/ML) Consumption

“The Most Efficient Pump doesn't necessarily result into Least (Pumping Station) Energy Consumption....!”

- M. N. Gowaikar, Consulting Engineer

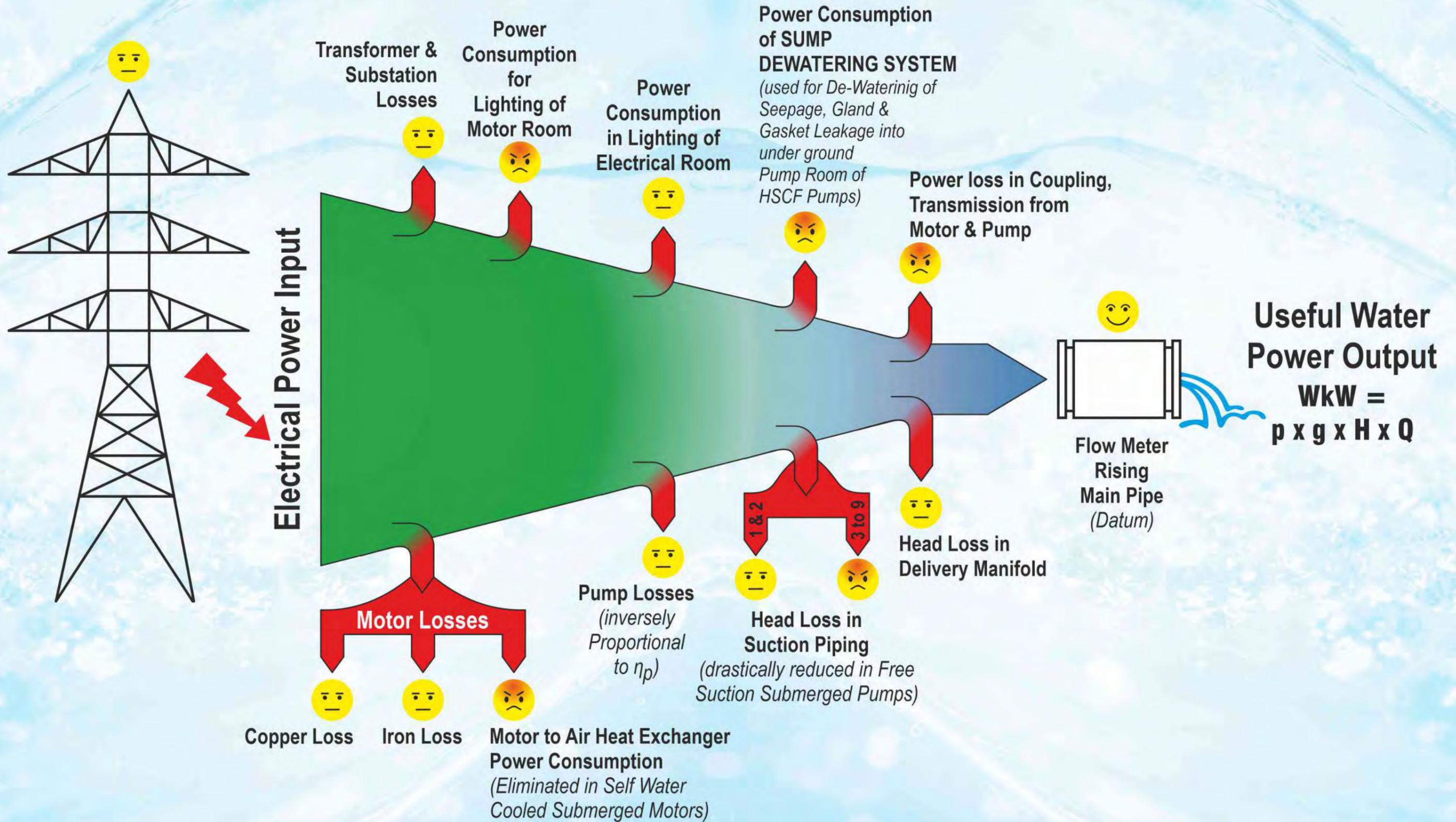
Corollary

*ALL these Cars use the SAME ENGINE (FIAT 1.3L MultiJet Turbo Diesel)
& hence have Similar ENGINE EFFICIENCY i.e. Diesel Consumed (l) / Power Generated (hp) is the same.....*

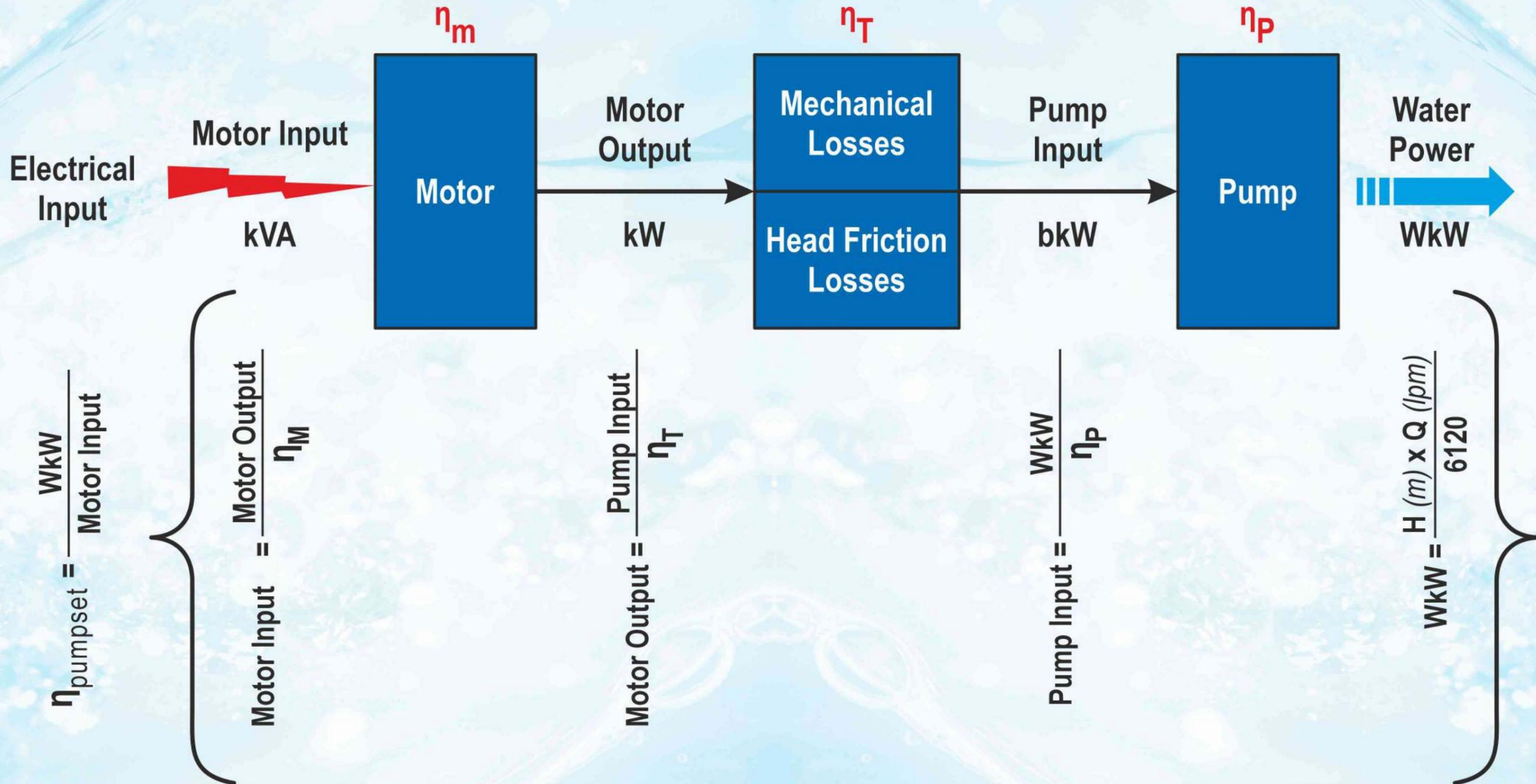


*.....but due to Different Ancillaries & Auxiliaries;
Car's Mileage (Distance Travelled / Diesel Consumed (km/l)) are DIFFERENT...!*

Power Flow Chart



PumpSet : Energy Flow Diagram



Bowl Efficiency \neq Pump Efficiency

HI 12.1-12.6 *Rotodynamic (Centrifugal) Slurry Pumps for Nomenclature, Definitions, Applications, and Operation*).

- h) **Thrust balance:** Pumps often use varying methods of hydraulic thrust balance, which may reduce the pump efficiency.
- i) For multistage vertical turbine (diffuser) type pumps, there will be a difference between attainable bowl efficiency and attainable pump efficiency.
 - **Staging effect:** Due to hydraulic losses at the inlet and discharge of the pump, single-stage attainable efficiency could be as much as 6 points below the bowl efficiency. This difference decreases as the number of stages increases. Typically this correction applies to four stages and less.
 - **Pump efficiency:** Overall pump efficiency will be less than attainable bowl efficiency due to hydraulic losses in the column piping, discharge elbow losses, and bearing losses. Because of the variability in this style pump, this correction needs to be analyzed for each application.

Seemingly Innocent Couplings also Waste Energy

(i.e. if their efficiency is 99% they waste 1% Energy)



PUMP LIFE CYCLE COSTS

A GUIDE TO LCC ANALYSIS
FOR PUMPING SYSTEMS

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η_{pump}

!.. $\eta_{coupling}$..!

η_{motor}



Power Transmission

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E.2 Power Transmission

E.2.1 Efficiency and Characteristics of Various Types of Transmissions

E.2.1.1 Mechanical couplings

Mechanical couplings are the most common method used for transmitting power to pumps. Mechanical couplings are possibly the most efficient mechanical device available for transmitting power. Losses are primarily caused by windage and are almost negligible. In general, efficiencies will range from above 99 percent down to 98 percent. Because of the very high efficiencies, selecting the type of coupling to use is based primarily on factors other than efficiency.

Couplings generally can be divided into two basic types: rigid and flexible. Rigid couplings are used on vertical pumps and are very seldom used on horizontal pumps. They are used primarily to extend a shaft where the shaft and extension must act as a single unit. Virtually all horizontal pump drives use some type of flexible coupling.

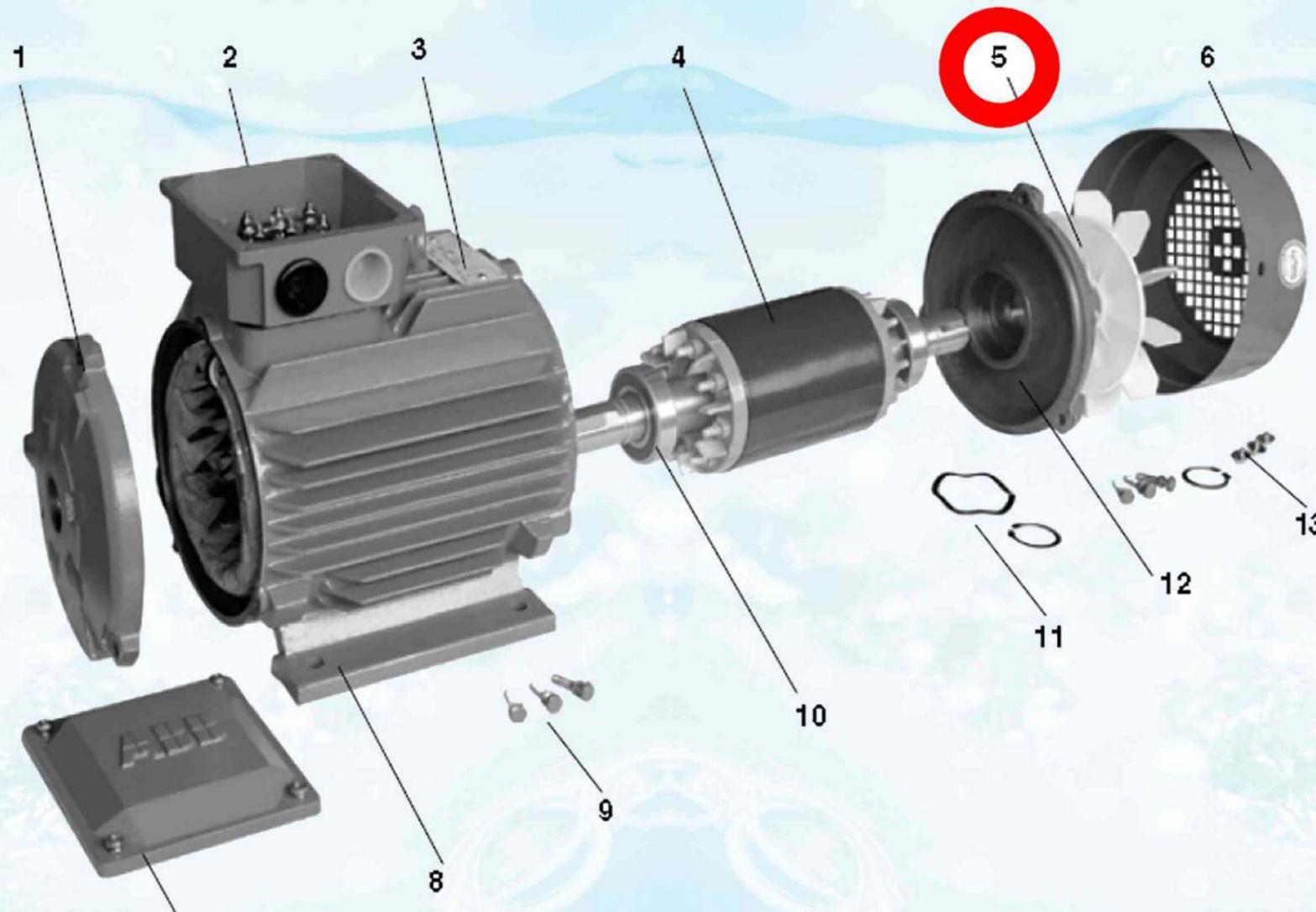


Source : "Pump Life Cycle Costs" from HIS & EURO Pump

Pumping Stations - Wire to Water Specific Power Consumptions_r1 : 06

Motor Efficiency : Power Loss due to Mode of Cooling

Air Cooled Induction Motors are Cooled by a Fan/ Heat Exchanger which draws power from motor shaft & hence has a Parasitic effect on Motor Efficiency –i.e. if this fan is removed (like in Totally Enclosed Self Water Cooled (TESWC) Motors) then Motor's Wire to Shaft Efficiency would improve.



$$\eta_m = \frac{\text{Output}}{\text{Input}} = \frac{\text{Output}}{\text{Output} + \text{Losses}}$$

$$\eta_{\text{TESWC}} = \frac{835 \text{ kW}}{860.8 \text{ kW}} = \frac{835 \text{ kW}}{835 + 25.8 \text{ kW}} = 97.0\%$$

(Submerged Self Water Cooled)

$$\eta_{\text{TETV/CACA}} = \frac{835 \text{ kW}}{877.1 \text{ kW}} = \frac{835 \text{ kW}}{835 + 42.1 \text{ kW}} = 95.2\%$$

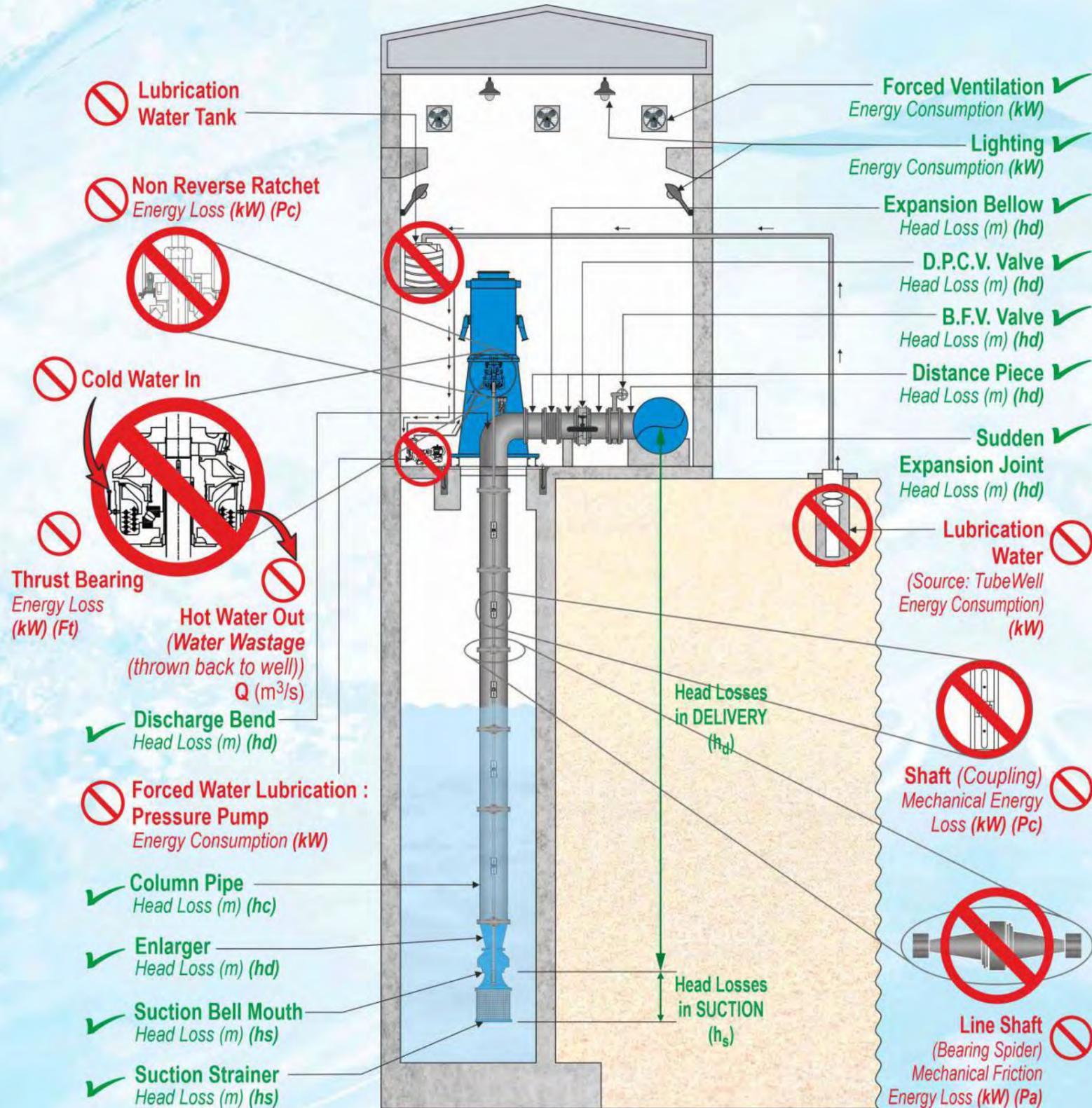
(Air Blower Cooled Motor)

Pumping Station's Wire to Water Specific Power (kW/ML) Consumption

Legend :

Ancillaries / Auxiliaries / Components marked **RED** (⊘) indicate that they are **Not required / required in Lesser Quantity** in SubCF pumps (& hence their **Losses / Parasitic Energy Wastage is also automatically Eliminated**).

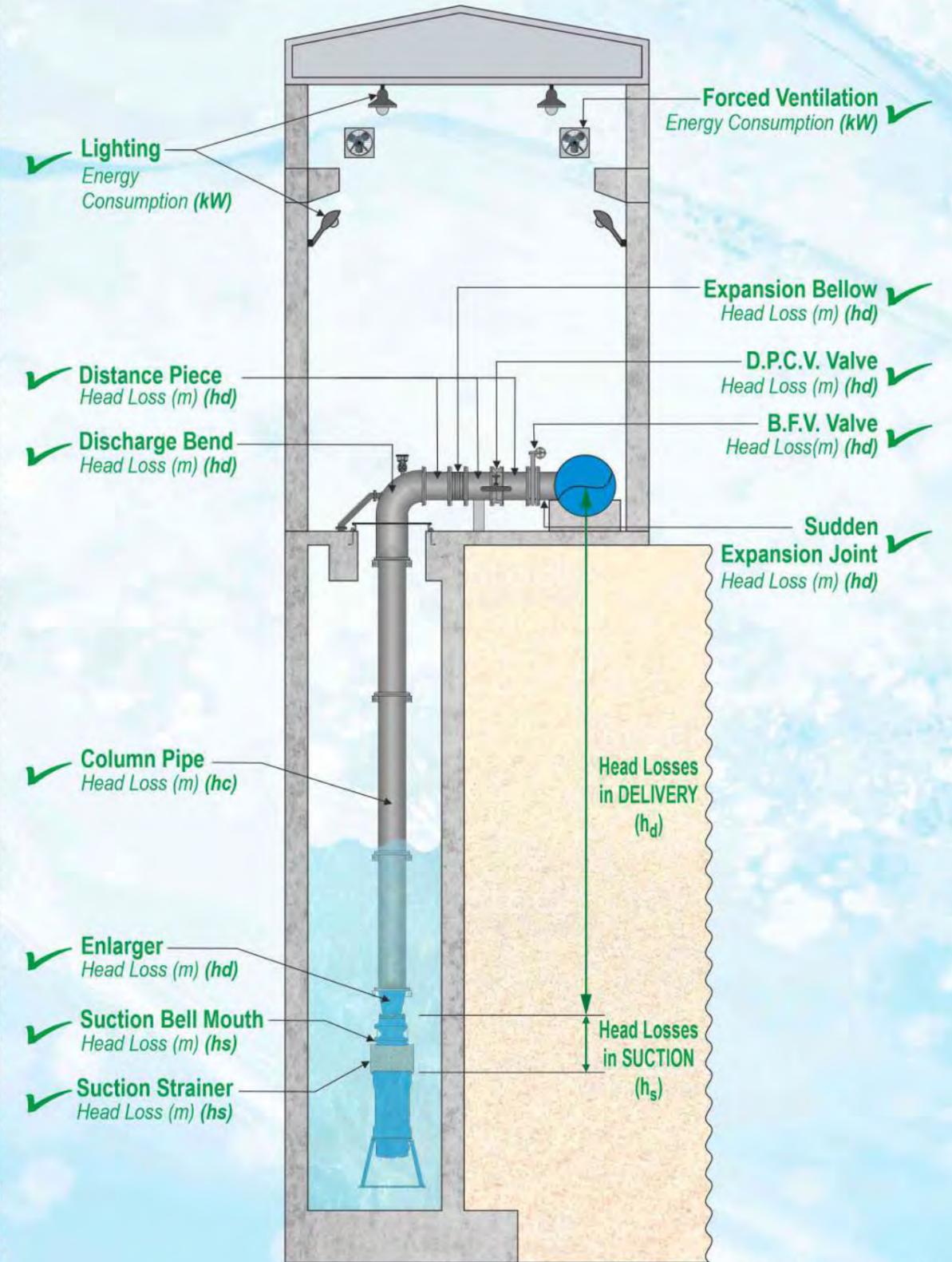
VT based Pumping Station



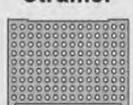
Legend :

Ancillaries / Auxiliaries / Components marked **GREEN** (✓) indicate that they are **common** in all Pump / Pumping Stations types (& hence their **Losses / Parasitic Energy Wastage is also unavoidable**).

SubVT based Pumping Station



Energy & Efficiency Comparison • VT v/s SubVT (Detailed Calculation) •

PROJECT : ****																		
S.No.	Description	Unit	Type of Pumpsets		Remarks	S.No.	Description	Unit	Type of Pumpsets		Remarks	S.No.	Description	Unit	Type of Pumpsets		Remarks	
			VT	SubVT					VT	SubVT					VT	SubVT		
1	Total Capacity	MLD	150		–													
2	Working Hours Per Day	hr	22		–													
3	Pumpsets Quantity	Working	Nos	4														
		Stand-by	Nos	1		–												
4	Pumpset's Rated (Duty Point) @ Discharge Bend	(Effective) Head (h)	m	27														
5		(Effective) Discharge (Q)	l/s	473.5														
6			m ³ /hr	1704.5														
7	Thrust Bearing Cooling Water (Leakage)	Q Thrust Bearing Leakage / Q Pump Rated Discharge	%	0.09	0.00													
8		Q / Pump	m ³ /hr	1.53	0.00													
9	Q Bowl @ Nozzle	m ³ /hr	1706.1	1704.5	–													
10	Pump's Water Power (p)	kW	125.3	125.3	–													
11	Pump Delivery	Nozzle Size	mm	300														
12	Delivery Pipe	Size	mm	400														
13		Length	m	10														
14		Hazen Williams Constant	C	140														
15	Suction (Head) Losses (h_s)	15.1		Loss Factor "K"	K Value (Resistance Co-Efficient)	0.5	0.5	Strainer Losses = KxV ² /2g										
				Loss	m	0.025	0.025	K Value Assumed = 0.5										
		15.2		Loss Factor "K"	K Value (Resistance Co-Efficient)	0.5	0.5	Bell Mouth Losses = KxV ² /2g										
				Loss	m	0.363	0.362	K value from CPHEEO Water Manual Table : 6.5										
Sub TOTAL		m	0.39	0.39	–													
16	Delivery (Head) Losses (h_d)	16.1		Loss Factor "K"	K Value (Resistance Co-Efficient)	0.5	0.5	Enlarger Losses = KxV ² /2g										
				Loss	m	1.145	1.145	K Value Assumed = 0.5										
		16.2		Loss	m	0.55 (Fig.5 in IS 1710)	0.16	For Sub. Pump = 3.35x10 ⁶ Q (l/s) / d2.63 C										
		16.3		Loss	m	0.50 (Fig.6 in IS 1710)	0.36	For Sub. Pump = K x V ² /2g K value from CPHEEO Water Manual Table : 6.5										
Sub TOTAL		m	3.25	2.72	–													
17	Bowl Assembly Head (H) = 4+15+16 to be developed by bowl to overcome ALL Head Losses upto Discharge Nozzle	m	30.63	30.11	–													
16	Delivery (Head) Losses (h_d)	16.4		Length	m	0.5	0.5	Distance Piece Losses = 3.35 x 10 ⁶ Q (l/s) / d ^{2.63} C										
				Loss	m	0.012	0.012	C value from CPHEEO Water Manual Table : 6.1 (Page No : 108)										
		16.5		Loss Factor "K"	K Value (Resistance Co-Efficient)	0.5	0.5	Bellow Losses = KxV ² /2g										
				Loss	m	0.362	0.362	K value from CPHEEO Water Manual Table : 6.5										
		16.6		Length	m	0.5	0.5	Distance Piece Losses = 3.35 x 10 ⁶ Q (l/s) / d ^{2.63} C										
				Loss	m	0.012	0.012	C value from CPHEEO Water Manual Table : 6.1 (Page No : 108)										
		16.7		Loss Factor "K"	K Value (Resistance Co-Efficient)	0.3	0.3	Valve Losses = KxV ² /2g										
				Loss	m	0.217	0.217	K value from CPHEEO Water Manual Table : 6.5										
		16.8		Length	m	0.5	0.5	Distance Piece Losses = 3.35 x 10 ⁶ Q (l/s) / d ^{2.63} C										
				Loss	m	0.012	0.012	C value from CPHEEO Water Manual Table : 6.1 (Page No : 108)										
		16.9		Loss Factor "K"	K Value (Resistance Co-Efficient)	0.3	0.3	Valve Losses = KxV ² /2g										
				Loss	m	0.217	0.217	K value from CPHEEO Water Manual Table : 6.5										
		16.10		Loss Factor "K"	K Value (Resistance Co-Efficient)	0.3	0.3	Sudden Expansion Joint Losses = KxV ² /2g										
				Loss	m	0.217	0.217	K value from CPHEEO Water Manual Table : 6.5										
Sub TOTAL		m	3.25	2.72	–													
17	Bowl Assembly Head (H) = 4+15+16 to be developed by bowl to overcome ALL Head Losses upto Discharge Nozzle	m	30.63	30.11	–													
18	Bowl Efficiency (η_b)	%	85.00	84.50	From HIS 2010													
19	Bowl Assembly Input Power (P_b)	kW	167.4	165.4	–													
20	(Mechanical -Friction) Line Shaft (IF applicable) Losses (P_{al})	kW	2.00	0.00	For VT Pump = (Fig.7 in IS 1710)													
21	(Mechanical) Thrust Bearing (IF External TB is provided) Losses (P_c)	kW	0.60	0.00	From SKF													
22	Pump Input Power (P) = 19+20+21	kW	170.0	165.4	–													
23	Pump Efficiency (η_p)	%	73.71	75.78	–													
24	Coupling Efficiency (IF provided) (η_c)	%	99.00	–	From HIS & Euro Pumps Standard													
25	Non-Reverse Ratchet Efficiency (IF provided) (η_c)	%	99.75	–	–													
26	Coupling + Non-Reverse Ratchet (Mechanical) Losses (If Provided) (P_c)	kW	2.13	0.0	–													
27	(Mechanical) Power Drawn From (Driver) Motor = 22+26	kW	172.2	165.4	–													
28	Forced Water Lubrication system (IF applicable for Line Shaft lubrication) (Electrical) Power Consumption (of forced water pumping system)	Power Consumed to Source Forced Water	kW	1.10	0.00	–												
		Power Consumed to Pressurize Forced Water	kW	1.85	0.00	–												
29	Motor Rating Offered	kW	200	200	–													
30	Motor Efficiency (η_m)	%	95.10	95.40	–													
31	Motor Terminal Input (Electrical) Power Consumed (PumpSET) (P_{mi}) = 27/30	kW	181.0	173.4	–													
32	Overall (PumpSET) Efficiency (η_O) = 10/31	%	69.23	72.29	–													
33	TOTAL Electrical Power Consumed (PumpSET + Forced Water Lubrication system)	kW/hr	183.99	173.37	–													
		kW-hr / Day	16,192	15,257	–													
34	Energy Consumption in Lighting	Unit Rating	kW	0.10	0.10	–												
		Quantity/W+S	nos	5	3	–												
		Working hr/day	hr	12	12	–												
		Total Power	kW/Day	6.00	3.60	–												
35	Energy Consumption in Forced Ventilation	Current	A	3.8	3.8	–												
		Volt	v	240	240	–												
		Power Factor	cos φ	1	1	–												
		Power	kW	0.9	0.9	–												
		Quantity of Fans	nos	4	2	–												
Total Power		kW/Day	80.26	40.13	–													
36	Total Auxiliary & Ancillary Power Consumption = 34+35	Unit Rating	kW/Day	86.3	43.7	–												
37	Transformer, Electrical Substation & Miscellaneous Losses	kW/Day	406.9	382.5	–													
38	Pumping Station (P.S.)	PS.Total Power Consumed	kW/Day (33-36+37)	16,685	15,683	–												
		PS. Efficiency (Wire to Water)	%	66.1	70.3	–												
		Specific Power Consumption	kW/ML	111.2	104.6	–												

Despite having (slightly) Lower Pump Bowl Efficiency, Submerged pump based Pumping Station consumes (slightly) Lower Energy...!

Pumping Station's Wire to Water Specific Power (kW/ML) Consumption



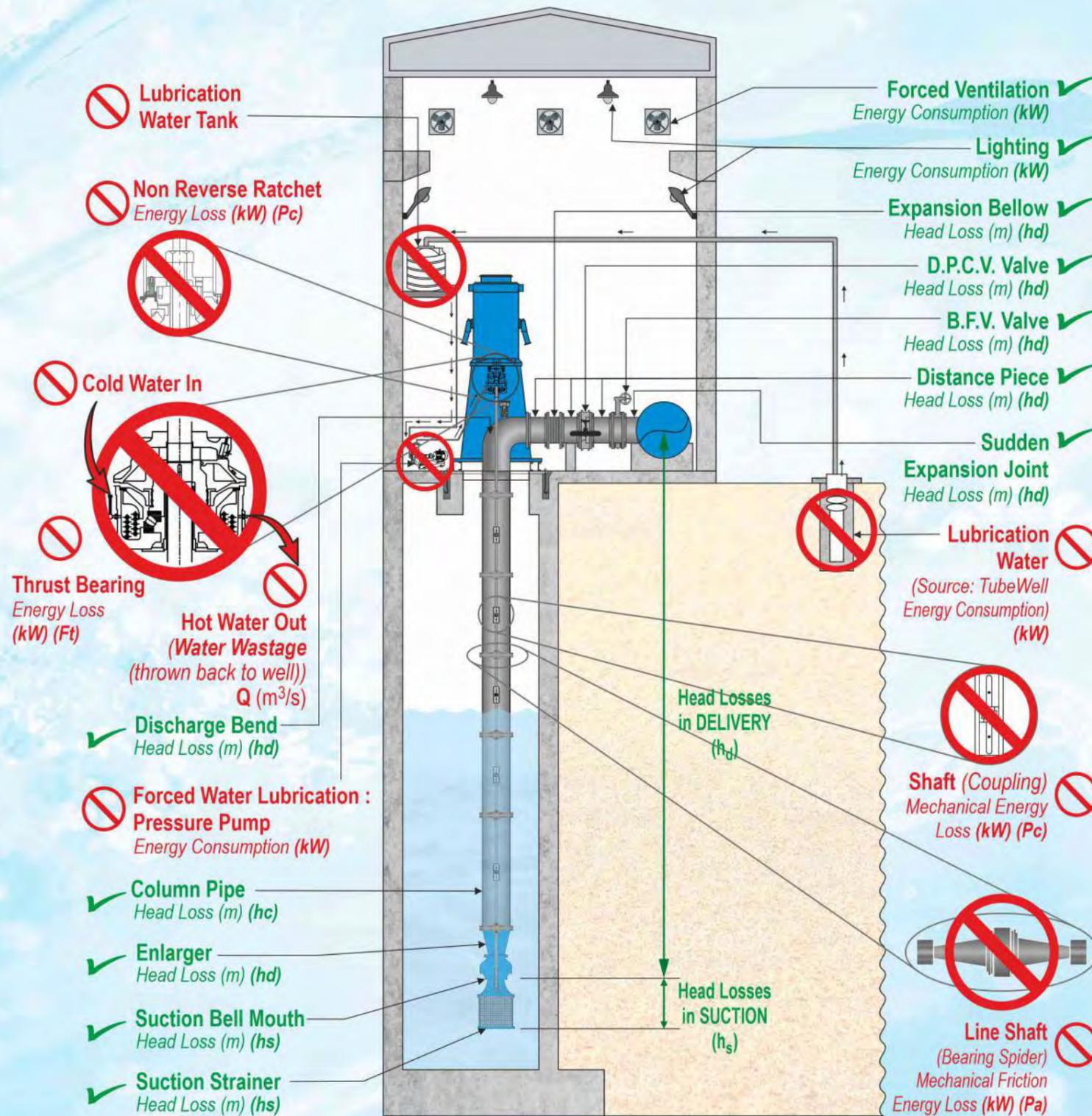
Legend :

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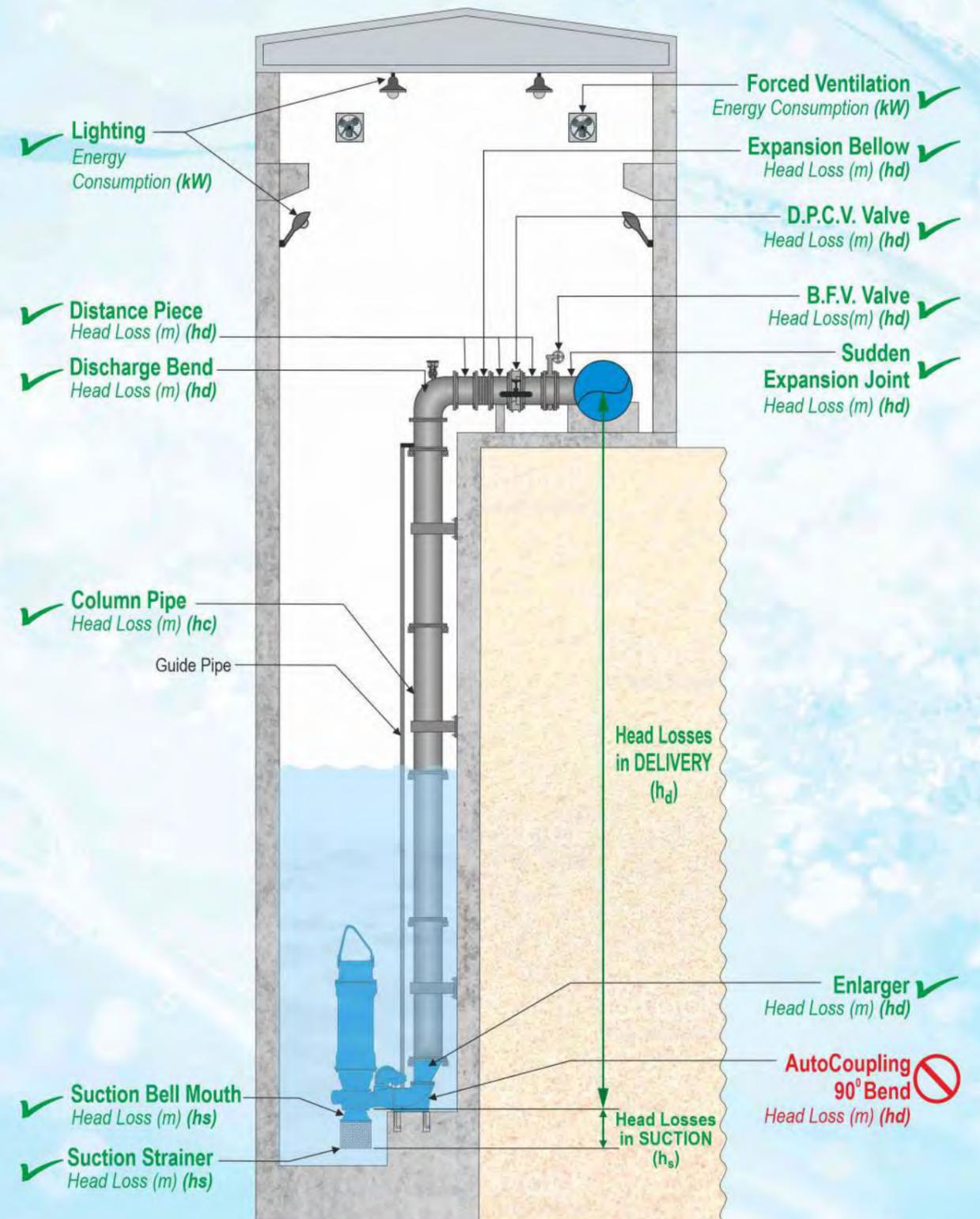
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VT based Pumping Station



SubCF based Pumping Station

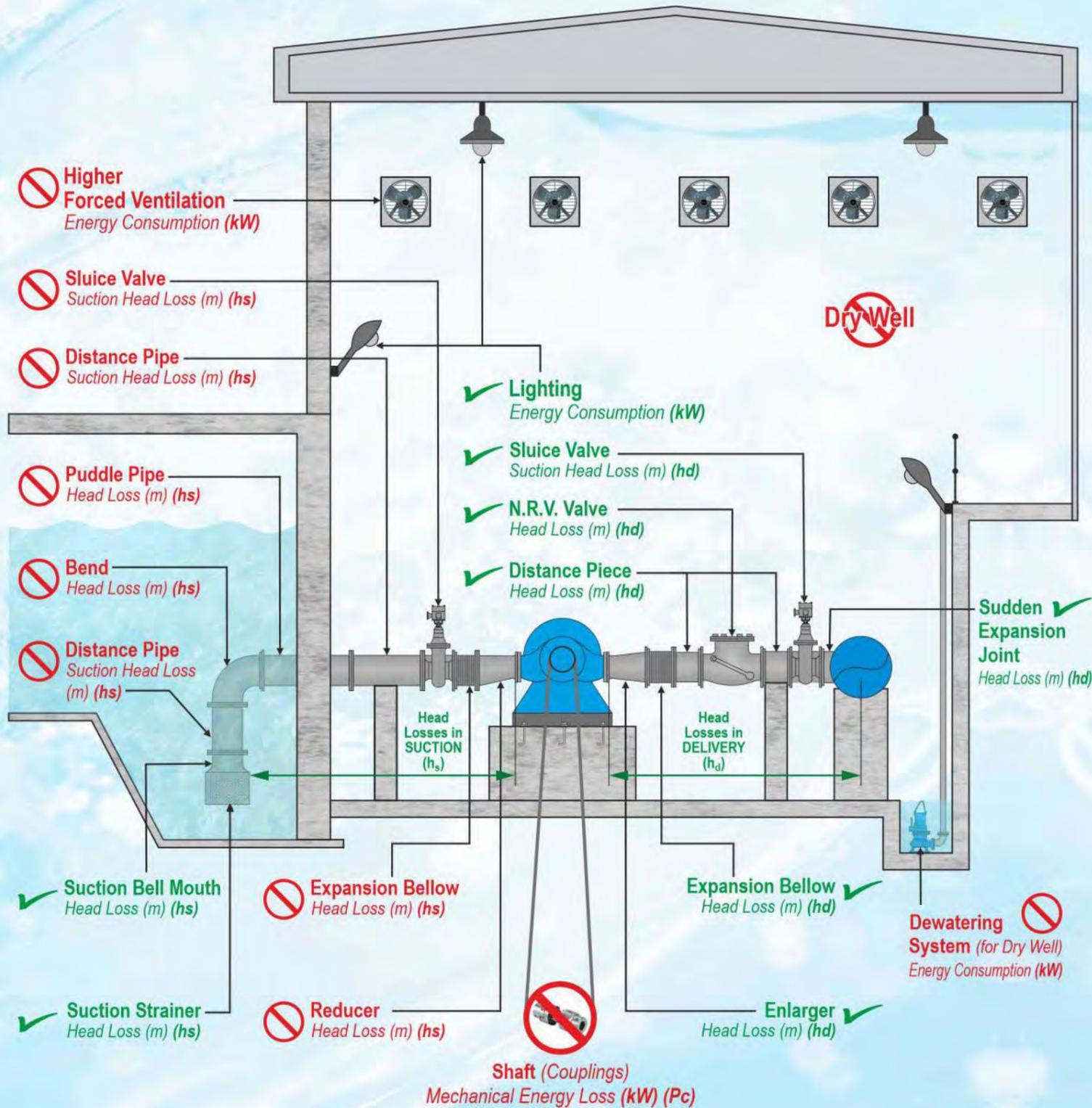


Pumping Station's Wire to Water Specific Power (kW/ML) Consumption

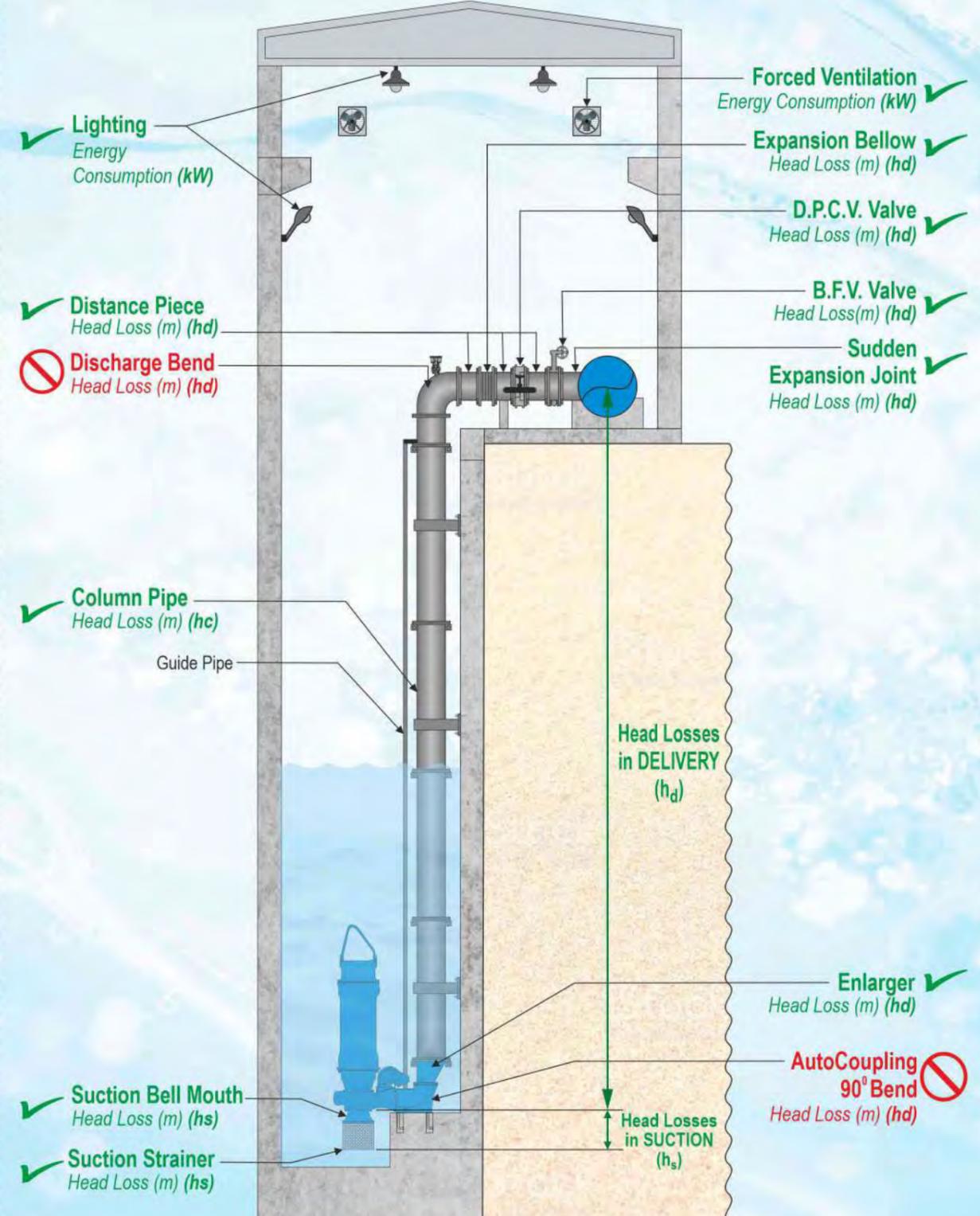
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• HSCF based Pumping Station •

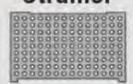
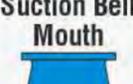
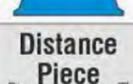
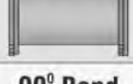
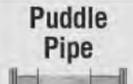
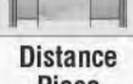
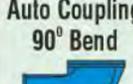
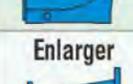


• SubCF based Pumping Station •



Energy & Efficiency Comparison

HSCF v/s SubCF (Detailed Calculation)

PROJECT : ****																			
S.No.	Description	Unit	Type of Pumpsets		Remarks	S.No.	Description	Unit	Type of Pumpsets		Remarks	S.No.	Description	Unit	Type of Pumpsets		Remarks		
			HSCF	SubCF					HSCF	SubCF					HSCF	SubCF			
1	Total Capacity	MLD	150																
2	Working Hours Per Day	hr	22																
3	Pumpsets Quantity	Working	4																
4		Stand-by	1																
5	Pumpset's Rated (Duty Point) @ Discharge Bend	(Effective) Head (h)	27																
6		(Effective) Discharge (Q)	473.5																
7			1704.5																
8	Pump's Water Power (p)	kW	125.3																
9	Pump Delivery	Nozzle Size	300																
10	Delivery Pipe	Size	400																
11		Hazen Williams Constant	140																
12	Suction (Head) Losses (h_s)	12.1		Loss Factor "K"	K Value (Resistance Co-Efficient)	0.5	0.5	Strainer Losses = $KxV^2/2g$	Loss	m	0.025	0.025	K Value Assumed = 0.5						
		12.2		Loss Factor "K"	K Value (Resistance Co-Efficient)	0.5	0.5	Bell Mouth Losses = $KxV^2/2g$	Loss	m	0.362	0.362	K value from CPHEEO Water Manual Table - 6.5						
		12.3		Distance Piece Losses = $3.35 \times 10^6 Q (l/s) / d^{2.63} C$	Length	m	0.5												
				Loss	m	0.012													
		12.4		Loss Factor "K"	K Value (Resistance Co-Efficient)	0.75													
				Loss	m	0.543													
		12.5		Distance Piece Losses = $3.35 \times 10^6 Q (l/s) / d^{2.63} C$	Length	m	2.0												
				Loss	m	0.049													
		12.6		Distance Piece Losses = $3.35 \times 10^6 Q (l/s) / d^{2.63} C$	Length	m	0.5												
				Loss	m	0.012													
12.7		Loss Factor "K"	K Value (Resistance Co-Efficient)	0.3															
		Loss	m	0.217															
12.8		Loss Factor "K"	K Value (Resistance Co-Efficient)	0.5															
		Loss	m	0.362															
13	Delivery (Head) Losses (h_d)	13.1		Loss Factor "K"	K Value (Resistance Co-Efficient)		0.5	Bend Losses = $KxV^2/2g$	Loss	m	0.000	1.145	K value from CPHEEO Water Manual Table - 6.5						
		13.2		Loss Factor "K"	K Value (Resistance Co-Efficient)	0.5	0.5	Enlarger Losses = $KxV^2/2g$	Loss	m	1.145	1.145	K Value Assumed = 0.5						
				Loss	m	1.145													
		13.3		Loss	m	0.00	0.36	For Sub. Pump Losses = $KxV^2/2g$	Loss	m	0.00	0.36	K Value Assumed = 0.5						
		13.4		Loss Factor "K"	K Value (Resistance Co-Efficient)	0.5	0.5	Bellow Losses = $KxV^2/2g$	Loss	m	0.362	0.362	K value from CPHEEO Water Manual Table - 6.5						
				Loss	m	0.362													
		12.3		Distance Piece Losses = $3.35 \times 10^6 Q (l/s) / d^{2.63} C$	Length	m	0.5	0.5											
				Loss	m	0.012	0.012												
		13.6		Loss Factor "K"	K Value (Resistance Co-Efficient)	0.3	0.3	Valve Losses = $KxV^2/2g$	Loss	m	0.217	0.217	K value from CPHEEO Water Manual Table - 6.5						
				Loss	m	0.217													
13.7		Distance Piece Losses = $3.35 \times 10^6 Q (l/s) / d^{2.63} C$	Length	m	0.5	0.5													
		Loss	m	0.012	0.012														
13.8		Loss Factor "K"	K Value (Resistance Co-Efficient)	0.3	0.3	Valve Losses = $KxV^2/2g$	Loss	m	0.217	0.217	K value from CPHEEO Water Manual Table - 6.5								
		Loss	m	0.217															
13.9		Loss Factor "K"	K Value (Resistance Co-Efficient)	0.3	0.3	Sudden Expansion Joint Losses = $KxV^2/2g$	Loss	m	0.217	0.217	K value from CPHEEO Water Manual Table - 6.5								
		Loss	m	0.217															
14	Bowl Assembly Head (H) = 5+12+13 to be developed by bowl to overcome ALL Head Losses upto Discharge Nozzle		m	31.13	31.08														
15	Pump (Bowl) Efficiency (η_p)		%	85.00	84.50													From HIS 2010	
16	Pump (Bowl) Assembly Input Power (P_b)		kW	170.00	170.73														
17	Coupling Efficiency (IF provided) (η_c)		%	99.00														From HIS & Euro Pumps Standard	
18	Coupling (Mechanical) Losses (IF Provided) (P_c)		kW	1.70	0.0														
19	(Mechanical) Power drawn from (Driver) Motor = 16+18		kW	171.7	170.7														
20	Motor Rating Offered		kW	200	200														
21	Resultant Motor Margin @ Duty Point		%	17.6	17.1														
22	Motor Efficiency (η_m)		%	95.1	95.4														
23	Motor Terminal Input (Electrical) Power Consumed (PumpSET) (P_{mi}) = 19/22		kW	180.6	179.0														
24	Overall (PumpSET) Efficiency (η_O) = 8/23		%	69.42	70.04														
25	TOTAL Electrical Power Consumed by PumpSET			kW/hr	180.55	178.96													
				kW-hr / Day	15,888	15,748													
26	Energy Consumption in Lighting of Electrical Room		Unit Rating	kW	0.10	0.10													
			Quantity/W+S	nos	6	6													
			Working hr/day	hr	12	12													
				Total Power	kW/Day	36.00	36.00												
27	Energy Consumption in Lighting of UnderGround Pump Room (Dry Well)		Unit Rating	kW	0.10	0.00													
			Quantity/W+S	nos	8	0													
			Working hr/day	hr	12	0													
				Total Power	kW/Day	48.00	0.00												
28	Energy Consumption in Auxillary Power Consumption of DeWatering System (used for DeWatering seepage, gland & gasket leakage dewatering of Dry well under ground pump room)		Unit Rating	kW	2.2	0.00													
			Quantity/W+S	nos	1	0													
			Working hr/day	hr	5	0													
				Total Power	kW/Day	44.80	0.00												
29	Energy Consumption in Forced Ventilation of UnderGround Pump Room (Dry Well)		Current	A	3.8	3.8													
			Volt	v	240	240													
			Power Factor	Cos θ	1	1													
			Power	kW	0.9	0.9													
			Quantity of Fans	nos	4	2													
				Total Power	kW/Day	80.26	40.13												
30	Total Auxiliary & Ancillary Power Consumption = 26+27+28+29		Unit Rating	kW/Day	209.1	76.1													
31	Transformer, Electrical Substation & Miscellaneous Losses		kW/Day	402.4	395.6														
32	Pumping Station (P.S.)		PS.Total Power Consumed	kW/Day (25+30+31)	16,500	16,220													
			Ratio		1.02	1.00													
			PS. Efficiency (Wire to Water)	%	66.8	68.0													
				Specific Power Consumption	kW/ML	110.0	108.1												

Despite having (slightly) Lower Pump Efficiency, Submerged pump based Pumping Station consumes (slightly) Lower Energy...!