Taj Holiday Village, Goa

Site Visit Report

1. Introduction

EDS had coordinated with the Taj Holiday Village, Elgressy and IFC representatives to organize the site visit on July 11 & 12, 2022. The following aspects were planned to cover during the site visit:

a. Witness the commissioning of EST system by Elgressy
b. Understand operation of EST system
c. Discuss on measurement and verification parameters
d. Set the baseline, installation, and reporting period
e. Collect the available baseline data

During the site visit, following members were present to execute various tasks planned for the pilot technology:

Mr. Athen Chellappa	– Chief Engineer, Taj Holiday Village, Goa
Mr. Rajkiran Gadekar	– Engineer, Taj Holiday Village, Goa
Mr. Brendon Mendona	– Technical Expert, IFC
Mr. Gaby Elgressy	– CEO, Elgressy Engineering Services Ltd.
Mr. Praveen Kumar	– Senior Project Manager, EDS

EDS would like to specially thank Mr. Athen and Mr. Rajkiran for the kind hospitality and efforts taken during the site visit to accomplish all the planned tasks. EDS would like to thank Mr. Brendon and Mr. Gaby Elgressy for their time and efforts without whom this site visit could not have been so much productive and effective.

2. Project brief

Taj Holiday Village, Goa is a part of the Indian Hotels Company Limited (IHCL) which has partnered with IFC's TechEmerge Sustainable Cooling Innovation (TE-SCI) program to pilot and scale energy-efficient, climate-smart cooling innovations across its properties. Approved pilot for Taj Holiday Village, Goa is Elgressy's solution which offers a comprehensive chemical free treatment for cooling towers preventing corrosion, algae and scaling in the cooling system and thus will lead to water savings. The solution is an automated plug and play system based on patented electrochemical technology enabling smooth chemical free treatment of 500 TR cooling tower.

The high side of HVAC system comprises of a 400 TR capacity chiller which is a centrifugal type and has twin compressors for its efficient operation. Each compressor has a capacity of 200 TR and its operation is modulated on the basis of changes in ambient conditions and system load. There are three primary pumps of 10 kW capacity while four secondary pumps are installed having 15 kW capacity. Facility has three condenser pumps of 22 kW capacity which supplies water to 2 cooling towers of 500 TR capacity each.

Energy metering provision is provided for each chiller, primary pump, secondary pump, condenser pump and cooling tower. Below are the photos of each equipment part of the high side of HVAC system:

a. Chiller (400 TR centrifugal chiller)

Figure 1: Chiller

b. Primary pumps (3 units, 10kW each)

Figure 2: Primary pumps

c. Secondary pumps (4 units, 15 kW each)

Figure 3: Secondary Pumps

d. Condenser pumps (3 units, 22 kW each)

Figure 4: Condenser Pumps

e. Cooling Towers (2 units, 500 TR each)

Figure 5: Cooling towers

f. Building Management System

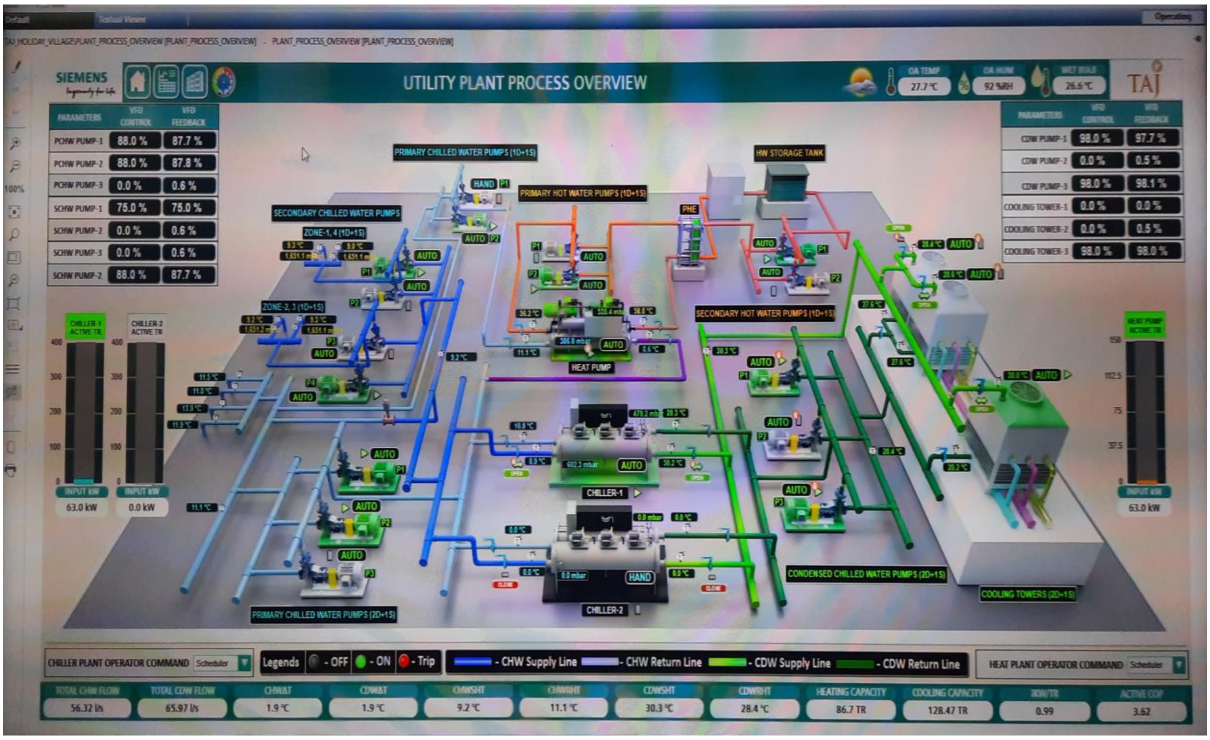

Figure 6: Building Management System

The facility has the Building Management System (BMS) in which the high side of the HVAC system is monitored and controlled.

Facility had replaced the old equipment part of HVAC system (high side) with the efficient equipment in Feb 2022. Under this initiative, energy efficient chiller, primary pumps, secondary pumps, condenser pumps and cooling towers were commissioned by February 2022. As a latest addition to the HVAC system, a cooling tower 500 TR of Advance make was commissioned during June 2022.

The low side of HVAC system mainly comprise of Fan Coil Units (FCUs) and ventilation fans. Since the pilot does not focus on the low side of HVAC system, more details are not provided in this report.

3. Water quality before commissioning of EST system

Cooling towers are used for removing waste heat from the utility and process applications. The purpose of cooling tower is to conserve water as well. A cooling tower performance is assessed by understanding its effectiveness but at the same time, it is also important to access how much water it is recycling back to the point of exchange. So, the operation of cooling tower is best measured in terms of how efficiently it reduces freshwater withdrawals and waste waster discharge while assessing how much heat it is dissipating to the atmosphere. A cooling tower efficiency can be improved by increasing the cycles of concentration. To understand this, it requires a practical understanding of the various water quality parameters.

Cycles of Concentration is defined by the ratio of the dissolved solids in the cooling tower water to the dissolved solids in makeup water. The COC specifies, how often a fresh water added into the loop, can be used or pumped around, before the water has to blow down or bleed off from the cooling tower.

Cooling towers achieve their purpose by rejecting waste heat to the atmosphere by latent and sensible heat transfer. Approximately 0.1% of the water that flows through the cooling tower is evaporated for every 1-degree temperature drop across the tower. The water that is evaporated is pure. That is, it does not contain any of the dissolved solids (minerals) contained in the cooling tower makeup. As a result, the dissolved solids concentrate in the cooling water over time. If this is allowed to continue without restriction, eventually the dissolved solids reach their solubility limit and precipitate as an insoluble scale or sludge in the heat exchangers, tower fill and basin.

To understand the water quality of circulating water and make-up water of the cooling tower, the engineering team had done the water quality test from ESSEM Enterprises on July 9, 2022. The result of the test is mentioned below:

Sr. No.	Parameter	Units	Make up water	500 TR (Single CT)
1	pH		7.3	7.8
2	TDS	mg/l	40	130
3	Calcium Hardness	mg/l as $CaCO_3$	10	30
4	Total Alkalinity	mg/l as $CaCO_4$	20	50
5	Conductivity	uS/cm	62	202
6	Chloride	mg/l as Cl	10	30
7	Silica	mg/l	<5	10
8	Algae		Absent	Absent

Cycle of Concentration = Calcium hardness of circulating water in cooling tower / Calcium hardness of make-up water

$$COC = 30 / 10 = 3$$

Since calcium carbonate is the primary scale-forming impurity in a majority of water supplies, the Langelier Saturation Index (LSI) is often used to determine the maximum permissible COC based on calcium carbonate solubility.

The Indian Standard "Treatment of water for cooling towers – Code of Practice" IS 8186 : 1999 provides guidelines for maintaining optimum cooling water quality to achieve for efficient operation of the cooling system. The standard gives indication of the tendency of water to cause scaling or corrosion as per below table:

Tendency of water	LSI
Extremely severe scaling	3
Very severe	2
Severe	1
Moderate	0.5
Slight	0.2
Stable water	0
No scaling, very slight tendency to dissolve scale/corrosive tendency	- 0.2
No scaling, slight tendency to dissolve scale/corrosive tendency	- 0.5
Moderate tendency	-1
Strong tendency	-2
Very strong tendency	-3

The LSI of the circulating water flowing in the cooling tower is calculated as shown below:

Sr. No.	Parameters	Unit	Water sample details	
			CT circulating water	CT Make-up water
1	pH Value	NA	7.8	7.3
2	Total Dissolved Solids	mg/L	130	40
3	Conductivity	uS/cm	202	62
4	Chloride (as Cl)	mg/L	30	10
5	Calcium hardness	mg/L as $CaCO_3$	30	10
6	Silica	mg/L	10	<5
7	Total Alkalinity	mg/L as $CaCO_3$	50	20
8	Algae presence	NA	Absent	Absent
9	Water temperature	Deg C	30	30
Langelier Saturation Index (LSI)		-	**-0.83**	**-2.15**

For illustration purposes, calculation of LSI for circulating water is shown below:

pHs = (9.3 + A + B) - (C + D)		8.63
A = [(Log_{10}(TDS)-1)/10]	A	0.11
B = -13.12*Log_{10}(Deg C+273) + 34.55	B	1.99
C = Log_{10}(Ca hardness)-0.4	C	1.08
D = Log_{10}(alkalinity as $CaCO_3$)	D	1.70
LSI = pH - pHs		**-0.83**

The results show that the LSI of circulating water before commissioning of EST system is **-0.83** which is the indication that the water has **slight corrosive** tendency. This water quality is attainted with the help of chemicals such as Scacil, Bionil, Corocil and BCDMH tablets. The LSI of make-up water is **-2.15** which shows **strong tendency** towards corrosion. Hence, maintaining of water quality will be important for efficient operation of the cooling system.

4. Commissioning of EST system

The EST 12-1-7 was installed by the engineering team before its commissioning on July 11 & 12, 2022. During the visit, Mr. Gaby Elgressy started with the presentation on EST technology and explained about the technology after which the team proceeded for commissioning of the EST system.

The below photos illustrate the commissioning activities done onsite:

Figure 7: Commissioning photos of EST system

Post commissioning of EST system on July 11, water analysis test was performed by Mr. Gaby Elgressy around 1600 hrs to 1730 hrs. The values of water quality parameters are mentioned in the below table:

Sr. No.	Parameter	Units	Make up water	500 TR (Single CT)
1	pH		7.4	8.1
2	TDS	mg/l	229	650
3	Calcium Hardness	mg/l as CaCO3	17.8	91
4	Total Alkalinity	mg/l as CaCO4	35.6	74.76
5	Conductivity	uS/cm	383	1065
6	Chloride	mg/l as Cl	35	125
7	Water temperature	Deg C	25	27.7
Cycles of Concentration (COC)		-	5.11	
Langelier Saturation Index (LSI)		-	-1.72	0.01

The LSI of circulating water has improved from -0.83 (as on July 9, 2022) to 0.01 post commissioning of EST system. LSI shows that the circulating water is of good quality. Heavy rainfall during the commissioning period has also improved the quality of water circulating in the cooling tower. It is recommended to perform repeated water tests in the post-monsoon period to calibrate the EST system according to the water parameters obtained in the laboratory.

Elgressy repeated the water test of make-up water and circulating water for the important parameters on July 12, 2022 and calibrated the EST system accordingly. Elgressy have shared below the mass balance sheet in their operation report.

T cold =	25	°C
T hot=	27.7	°C
CIRC =	258	m^3/h
COC=	7	
MU-temp	25	°C
Wind&Drift	0.02	% CIRC
working hours/day	24	
ESTflow	7	m^3/h
No. of EST units	1	
ΔCaCO3(g/m³)/unit	1	g/m^3
ΔT tower	**2.7**	°C
Evaporation	**1.29**	m^3/h
B	**0.16**	m^3/h
Wind&drift	**0.05**	m^3/h
ΔCaCO3 total	**7**	g/h
MU	**1.46**	m^3/h

CaCO3 with makeup Kg/day	(IN)	**0.63**
CaCO3 percipitated by EST Kg/day	(OUT)	**0.17**
CaCO3 by drift Kg/day	(OUT)	**0.11**
CaCO3 by BD (washing) Kg/day	OUT)	**0.34**

Project name:Taj Holiday Village Resort, Goa		MAKEUP	COC= 7 +EST	COC= 7 +EST +H2SO4
Ca	mg/L $CaCO_3$	17.8	91	91
Mg	mg/L $CaCO_3$	7	50	50
Na	mg/L	27.6	193	193
K	mg/L			
Total alk (M)	mg/L $CaCO_3$	35.6	216	178
Cl	mg/L	35.0	245	245
SO_4	mg/L			36
NO_3	mg/L			
F	mg/L			
SiO_2	mg/L			
pH		7.20	8.1	**8.0**
COND. Measured	µS/cm	383	1067	
COND. Calcd.	µS/cm	**178**	**1042**	**1060**
Δcoductivity	<= 10%	no	yes	no
Δions (%)	MU Analysis Accepted	**-0.028**	**-0.033**	**-0.034**
ADD (ppm) for ionic equ.	Na	0.01		
COC (Ca)		**1**	**5.1**	**5.1**
TDS		**115**	**747**	**738**
Kg H2SO4/day (98%)				**0**
LSI @ 25 C		**-1.9**	**0.5**	**0.2**
Ryznar SI		**11.0**	**7.2**	**7.5**
PSI Puckorious index		**11.4**	**7.4**	**7.7**

Figure 8: Mass balance calculation

The LSI of the circulating water with the EST system is 0.5 while the expected pH level in the cooling tower is 8.2.

Elgressy had adjusted the operation of the EST system to work with 7 COC (Cycle of Concentration). The EST system blow down is 160 Liters/hour while the make-up water flowrate is 1.46 m^3/hr.

The cooling tower was working with the following parameters as noted by Elgressy:

Parameters	Unit	Level
Circulation rate	m^3/hr	258
ΔT ^oC	Delta Temperature ^oC	2.27
COC	Number of concentration cycles	7

Elgressy had suggested two options for setting up the drain value of the EST system to work with 7 COC. This will result in less flushing which will save more water.

1st option will be to open the drain valve for 1 minute per hour.
2nd option is to open every 30 minutes for a period of 30 seconds.

Mr. Gaby Elgressy gave hands on training to the O&M team on operation and maintenance of the EST system.

5. Measurement & Verification

EDS discussed with Mr. Athen (Chief Engineer, Taj Holiday Village), Mr. Brendon (IFC) and Mr. Gaby (Elgressy) on the M&V parameters, baseline period, installation period and reporting period. The summary of the discussion is mentioned below:

Sr. No.	Parameters	Frequency	Baseline period	Reporting period	Remarks of meeting dated July 12, 2022
1	Chemical usage and frequency	Weekly	Jan 2022 - June 2022	Aug 2022 - July 2023	# Chemical usage is constant # Dosing is done on daily, weekly basis # Last 12 months data shared # IHCL is advised to avoid use of chemicals post commissioning of EST system to analyze its effects on the cooling system.
2	Electrical consumption of EST system	Monthly	-	Aug 2022 - July 2023	# Energy meter will be installed for energy accountability # IHCL will install energy meter before Aug 1, 2022
3	Water quality - pH, TDS,Calcium Hardness, Conductivity, Chloride, Silica, Total alkalinity, algae presence, water temperature at the time of testing (CT circulating and makeup water test report required)	Weekly	Jan 2022 - June 2022	Aug 2022 - July 2023	# Water quality test reports shared with EDS for the baseline period # IHCL will share the weekly water testing reports with Elgressy and EDS
4	CoC and LSI	Weekly	Jan 2022 - June 2022	Aug 2022 - July 2023	# Earlier water test reports excluding the report shared on July 9, 2022 does not have sufficient parameters to calculate LSI. # Elgressy and EDS will calculate the CoC and LSI from the shared water test reports
5	Make up water consumption	Daily	Jan 2022 - June 2022	Aug 2022 - July 2023	# Make-up water accountability commenced from April 2022 # IHCL will install water meter on 2nd cooling tower
6	Blowdown quantity	Daily	Jan 2022 - June 2022	Aug 2022 - July 2023	# IHCL will share the blowdown quantity data with EDS # IHCL to keep track of blowdown quantity from cooling tower and EST system
7	Chiller plant ikW/TR	Daily	Jan 2022 - June 2022	Aug 2022 - July 2023	#Chiller, pumps were newly installed in Jan 2022 # IHCL shared data with EDS from March 2022 till 13th July 2022

8	Cooling tower approach	Daily	Jan 2022 - June 2022	Aug 2022 - July 2023	# IHCL shared data with EDS from March 2022 till 13th July 2022
9	Energy consumption of Chiller, condenser pumps and cooling tower	Daily	Jan 2022 - June 2022	Aug 2022 - July 2023	# Daily reading of chiller, primary, secondary - 1 set # 2nd set - condenser + cooling tower # IHCL shared data with EDS from March 2022 till 13th July 2022
10	Opex cost reduction	Monthly	Jan 2022 - June 2022	Aug 2022 - July 2023	# IHCL will share the opex cost of chillers, pumps, and cooling tower. This includes cost of electricity, chemical, water and maintenance.

With the conclusion of site visit, progress was achieved on following key aspects of the pilot program:

a. Baseline period considered from Jan 2022 to June 2022
b. Installation period considered from July 12, 2022 to 31st July 2022
c. Reporting period will commence from Aug 1, 2022
d. Discussion done on the measurement and verification parameters of the pilot technology
e. Commissioning activities witnessed for the EST system
f. Hands on training given by Elgressy to the O&M team for operating & maintaining the EST system
g. Elgressy adjusted the EST system to work with 7 Cycle of Concentration
h. Available data for the baseline period was received by EDS
i. EST system needs to be calibrated again post monsoon as per water quality parameters of circulating water

Further changes may be required to the baseline period depending on the data shared by IHCL. The installation period will be utilized to understand the EST operation by the O&M team. IHCL will ensure that the data is recorded as per required frequency in the reporting period which is planned to commence from 1st Aug 2022.