A

PROJECT REPORT

ON

"Energy management and audit of hotel building"

UNDERTAKEN AT

"ITC Grand Chola Hotel, Chennai"

IN PARTIAL FULFILMENT OF

POST GRADUATE DIPLOMA IN ENERGY MANAGEMENT

MIT SCHOOL OF DISTANCE EDUCATION, PUNE.

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Student Registration No: MIT2020C00291

MIT SCHOOL OF DISTANCE EDUCATION PUNE - 411 038

YEAR 2021 - 23

To
The Director
MIT School of Distance Education,

Respected Sir,

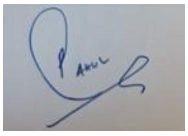
This is to request you to kindly exempt me from submitting the certificate from my organisation for Project Work due to the reason mentioned below:

Tick the right option
1. As per the Rules of the Organisation
2. Self Employed
3. Working in Public Sector
4. Full time Student

Thanking you in anticipation of your approval to my request.

Regards

RAHUL PRABHAKAR
Registration Number-MIT2020C00291

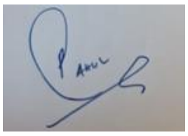


Signature

Declaration

I hereby declare that this project report entitled "**Energy management and audit of hotel building**" is a bonafide record of the project work carried out by me during the academic year 2021-2023, in fulfilment of the requirements for the award of POST GRADUATE DIPLOMA IN Energy Management (PGD) of MIT School of Distance Education.
This work has not been undertaken or submitted elsewhere in connection with any other academic course.

Students' Name – Rahul Prabhakar



Signature

Student ID: MIT2020C00291

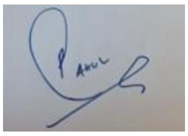
ACKNOWLEDGEMENT

I would like to take this opportunity to express my sincere thanks and gratitude to Mr HC Vinayaka of ITC Hotels Gurugram for giving me an opportunity to do my project work in your esteemed organization and it has indeed been a great learning and enjoyable experience.

I would like to express my deep sense of gratitude and profound thanks to all staff members of ITC Grand Chola, Chennai for their kind support and cooperation which helped me in gaining lots of knowledge and experience to do my project work successfully.

At last, but not least, I am thankful to my Family and Friends for their moral support, endurance and encouragement during the course of the project.

Students' Name – Rahul Prabhakar



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Student ID: MIT2020C00291

ABSTRACT

Climate change is one of the most challenging phenomena being faced by the humanity and India has been at the forefront of addressing this issue. India ratified the Paris Agreement in 2016 under which its member countries have given commitments to keep the global average temperature rise between 1.5-2 degree C by the mid of this century. India in its updated Nationally Determined Contributions (NDCs) has committed that it will reduce the emission intensity of its GDP by 45% by 2030 from 2005 level. Further, it has proposed to install 50% of the power capacity from non-fossil energy sources and aim to achieve net zero emissions by 2070. With a population of 1.4 billion, India has a massive demand for energy to fuel its rapidly growing economy. From a power deficit nation at the time of Independence, the efforts to make India energy-independent have continued for over many decades. Industrial investments in clean energy sources and enhancing energy efficiency are hailed as two of the most viable options for any country's decarbonisation efforts, at any level of development. Today, India is a power surplus nation with a total installed capacity of over 400 GW. Keeping in mind the sustainable development goals, India's power generation mix is rapidly shifting towards renewable energy. India is the world's third largest producer of renewable energy, with over 40% of its installed electricity capacity coming from non-fossil fuel sources. Given the importance of energy access, energy security and energy transition at the global and national level, a robust, consistent, and reliable energy data can help understand the energy profile of a country. It also helps in assessing the impact of various policies and programmes. In contemporary times where energy transition holds high priority, robust energy data can help policy makers formulate data backed policies which would support countries to achieve its environmental and developmental commitment in the coming years.

The hotel industry constitutes one of the most energy- and resource-intensive branches of the tourist industry. Substantial quantities of energy are consumed in providing comfort and services to guests, many of who are accustomed to, and willing to pay for exclusive amenities, treatment, and entertainment. The energy efficiency of the many different end-users in hotel facilities is frequently low, and the resulting environmental impacts are, therefore, typically greater than those caused by other types of buildings of similar size. The effects on the environment are caused by the excessive consumption of local/imported resources (e.g., water, food, electricity, and fuels), as well as by emissions released to air, water, and soil. The large quantities of waste products generated in hotel facilities pose a further significant environmental threat.

The industry, amid its diversity, faces certain common concerns about areas in which energy is wasted. Its diversity lies in the different kind of establishments it supports – be it large convention hotels, restaurants, guest houses, inns or motels. The varied nature of the physical facilities and the activities that they host can make energy management especially challenging.

The hospitality industry is increasingly focusing on better energy management as it looks to improve guest comfort levels while optimizing energy consumption. The effort is to reduce carbon footprint, bring in more energy efficiency by use of data-driven approaches and keep operational costs under check.

This project report talks about the data analytics-based approach to determine Energy Management and energy audit approach for the hospitality industry.

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CHAPTER 1

INTRODUCTION

With the enduring ITC Hotels is one of India's leading luxury hotel chains. It operates under four distinct brands with more than 130 hotels in over 70 destinations in the country. Integrating India's fine tradition of hospitality with globally benchmarked services, the luxury hotels reflect the culture and ethos of each destination. With 'Responsible Luxury' as its guiding premise, ITC's Luxury Collection hotels combine grandeur with intimacy to operate according to the highest principles of environmental stewardship. The brand features opulent accommodations, state-of the-art business facilities, renowned signature cuisine and award-winning wellness experiences.

Goals and Objectives of the Energy Management Programme

The Energy Management Programme provides the vital information base for overall energy conservation program covering essentially energy utilization analysis and evaluation of energy conservation measures. It aims at:

- Identifying the quality and cost of various energy inputs.
- Assessing present pattern of energy consumption in different cost centers of operations.
- Relating energy inputs and production output.
- Identifying potential areas of thermal and electrical energy economy.
- Highlighting wastages in major areas.
- Fixing of energy saving potential targets for individual cost centers.
- Implementation of measures for energy conservation & realization of savings

CHAPTER 2

ORGANIZATIONAL PROFILE

The ITC Grand Chola Hotel is a 5-star luxury hotel in Chennai, India. It is the third largest hotel in India. It is located in Guindy, opposite SPIC building.

General building or building complex details and descriptions –

The hotel, built on over 1,600,000 sq. ft, is dubbed the largest stand-alone hotel in the country built with an investment of INR 12,000 million. The hotel's 600 rooms include 522 rooms and 78 serviced apartments. The rooms include 326 Executive Club rooms, 31 Eva rooms, 132 Towers rooms, 48 ITC One rooms, 14 Deluxe Suites. The hotel saves over 40 percent of energy by means of various energy efficiency features. A 14.6-MW windmill caters to the power requirement of the hotel complex. The envelope materials of the building comprising composite wall assembly, multi-glazed windows, and roof-top insulation, well exceed the fenestration standards of ASHRAE/ECBC. Water is heated by means of solar concentrators. The hotel uses water-cooled refrigerants in place of air-cooled ones. All of the water requirements for irrigation, flushing, and cooling tower is met through treated effluent. The hotel has an onsite organic waste converter, capable of converting all of the organic waste produced daily into manure, installed. The hotel has obtained a Platinum Rating (the highest on the scale) from Leadership in Energy and Environmental Design (LEED), an internationally recognised green building certification system.

The hotel is currently the world's largest LEED-certified green hotel.

- Client: ITC Hotels
- Facility Name: ITC Grand Chola, Chennai
- Latitude – 13°00'38.2"N
- Longitude – 80°13'13.7"E
- Building Operation Since Year- 2012
- Building Operational Hours- 24 hours (Hospitality building)
- Climate zone- Warm and Humid
- Number of Floors: 3B+G+10
- Built-Up Area – 1,42,160 sqm.
- Conditioned Area – 96,739 sqm.
- Non-Conditioned Area – 45,421 sqm.
- Energy Audit Team: Design2Occupancy Services LLP (D2O)
- Air-Conditioned Area: More than 65%
- Contract Demand: 4000 kVA
- Connected Load: 5250 kW
- Employees Occupancy: 1100 approx. (60% Permanent & 40% Temporary)

CHAPTER 3

OBJECTIVES AND SCOPE OF PROJECT

Unlike other commercial buildings, hotels have unique energy requirements because of the variety of facilities available, functions provided and operational schedules. A hotel usually operates 24X7, round the year, although some sections such as the ballroom or a restaurant may be closed during specific periods in a day. Guest occupancy levels in hotels vary significantly across the year. In many hotels, even when a guestroom is not occupied, the air conditioning is kept switched on to prevent odor or guest discomfort. These factors contribute to the rising need for a specialized focus on Energy Management and Operational Effectiveness in the hospitality industry.

Advancements in IT, data convergence, and data analytics have found increased relevance in the way facility operations and management services are being delivered in the industry. Key Performance Indicators (KPIs) such as guest comfort, complaints, internal thermal and schedule policy compliance, energy consumption, benchmarking, etc. are being examined by hotel operators closely to understand and answer the "whats" and "whys," resulting in better insights into energy consumption and operations.

The energy use varies substantially between different types of hotels, and is affected by hotel size, class/category, the number of rooms, customer profile (guests visiting for business/on vacation), location (rural/remote or urban), climate zone, as well as by the types of services/activities and amenities provided to guests.
A hotel can be seen as the architectural combination of three distinct zones, all serving distinctly different purposes:

- The guest room area (bedrooms, bathrooms/showers, toilets) - individual spaces, often with extensive glazing, asynchronous utilization, and varying energy loads.
- The public area (reception hall, lobby, bars, restaurants, meeting rooms, swimming pool, sauna, etc.) - spaces with a high rate of heat exchange with the outdoor environment (high thermal losses) and high internal loads (occupants, appliances/equipment, and lighting).
- The service area (kitchens, offices, store rooms, laundry, staff facilities, machine rooms and other technical sections) – energy-intensive areas typically requiring advanced air handling (ventilation, cooling, heating).

The energy flows occurring in these three areas are usually very different, and need to be handled accordingly.
As per the energy use in hotels have shown that electricity is the primary source of energy in the hotel industry, while the shares of gas and oil are considerably smaller. The amount of electricity consumed in hotels is thus a good indicator of the overall energy expenditure in this sector. Energy costs in hotels typically amount to 3-10% of overall revenue.

The scope of the project is review energy management structure and conduct **energy audit** of major utilises in the hotel.

Chapter 4 – Data collection, analysis and interpretation

1.1 Formulation of Energy Audit Team –

The ITC Hotels team has performed energy audit of the facility. The team has performed physical inspection & performance testing of the equipment installed in the building and has reached to the results of the performance of the systems, analysed the energy consumption, traced out the fault in the process/equipment as findings, suggested the energy efficiency measures and respective cost analysis of the energy efficiency measures.

1.2 Component of Energy Cost -

The Energy cost majorly constitutes of following components:

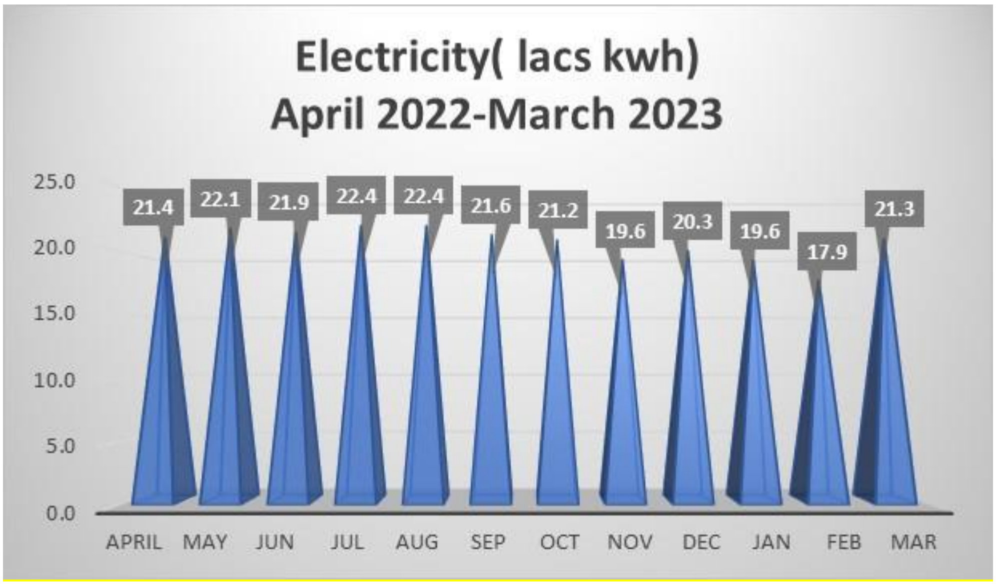
- Raw Energy Cost
- Capacity Cost
- Transmission Cost
- Ancillaries Cost
- Energy Losses Cost
- Renewable Portfolio Standard Cost

1.3 Major energy use area -The hospitality sector accounts for a large proportion of energy use. Following are the major energy use area:

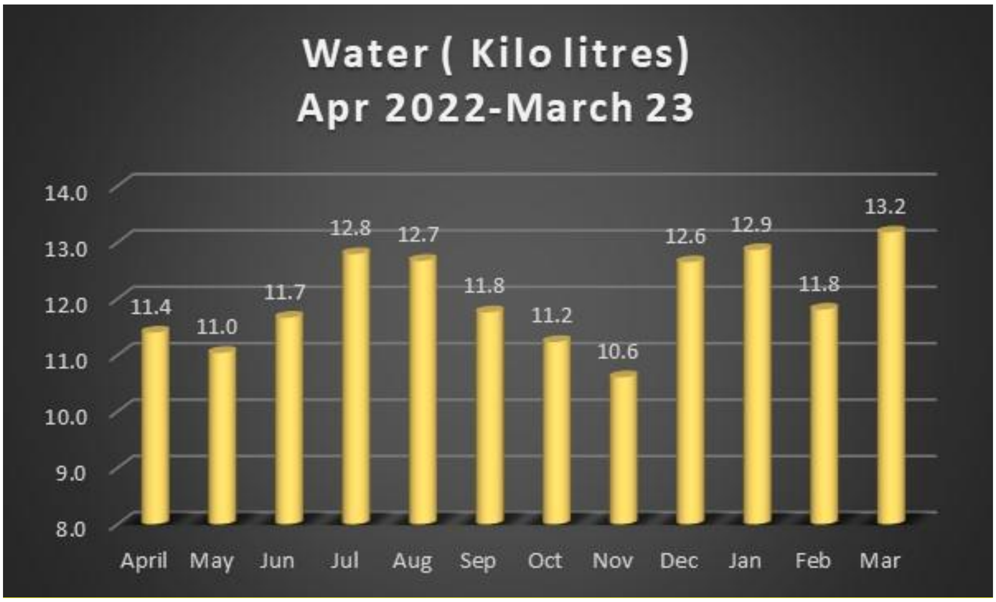
- Cooling
- Lighting
- Ventilation
- Space Heating
- Refrigeration & Cold Rooms
- Water Heating
- Kitchen equipment's
- Laundry equipment's
- Office equipments
- Motor Load

1.4 Analysis of Building Energy Consumption

The below table reflects the total electricity consumption (kWh) from the grid and Diesel Generator.



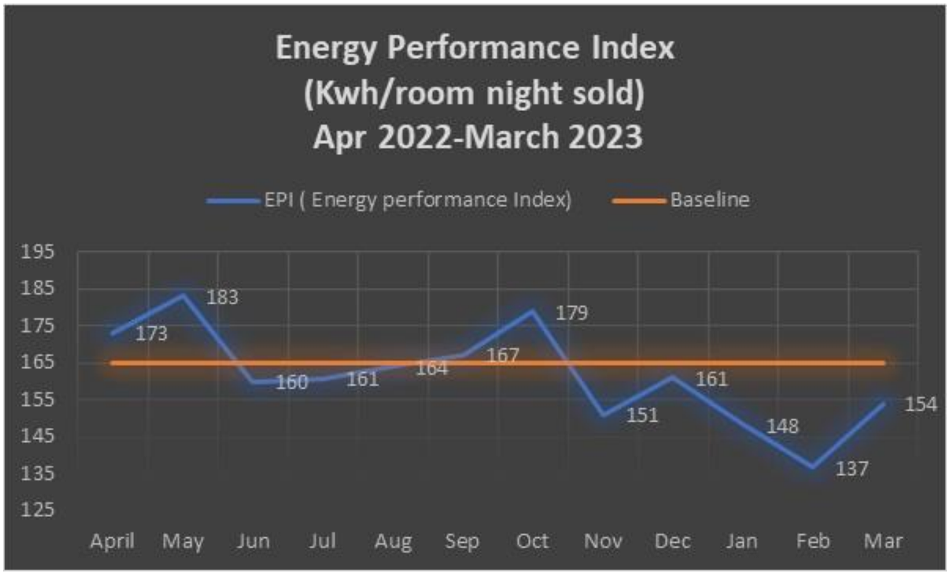
Graph – 1 – electricity consumption monthwise



Graph 2 – Water consumption monthwise

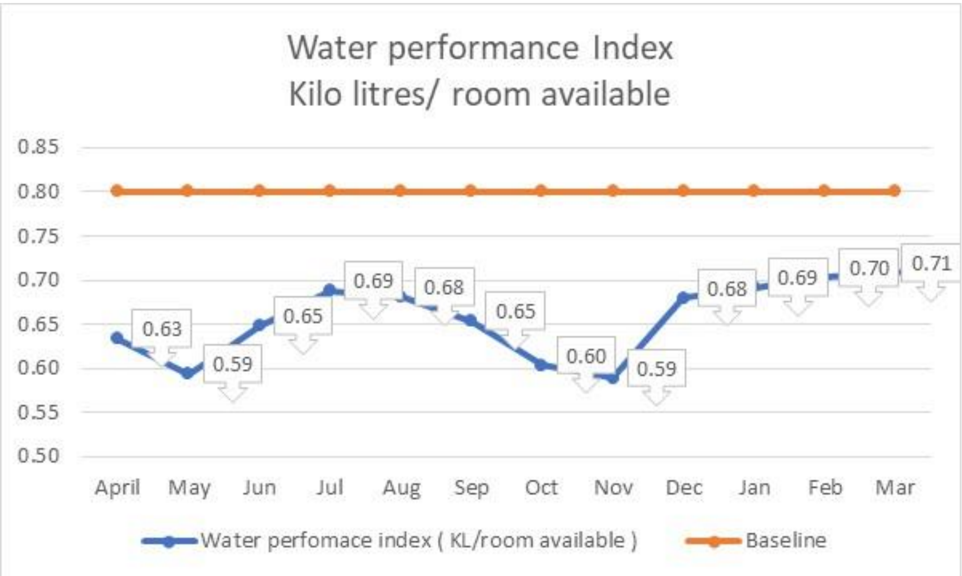
1.5 Energy and water Performance Index

Energy Performance Index (EPI) is the total energy consumed in a building over a year divided by room night sols (kWh/room night sold) and is considered as the simplest and most relevant indicator to analyse the energy efficiency of a building.



Graph – 3 - Energy performance Index

Interpretation – From the above analysis, it is clear that the unit is operating below the benchmark defined. There exist a scope for improvement and needs to be further explored.



Graph – 4 - Water performance Index

Interpretation – From the above analysis, it is clear that the unit is operating below the benchmark defined. There exists a scope for improvement and needs to be further explored.

2. Energy and Utility System Description

2.1 List of Utilities

* **HVAC High Side**

- Water-cooled Chillers
- Chilled water Pumps
- Condenser water Pumps
- Steam Boilers
- Heat Pumps

* **HVAC Low Side**

- Air Handling Unit
- Treated Fresh Air Unit
- Fan Coil Unit
- Ventilation Fans (Jet fans, exhaust fans, lifts & Staircase pressurization fans)

* **Electrical System**

- Automatic Power Factor Controller (APFC)
- Uninterruptible Power Supply (UPS)
- Diesel Generator (DG Sets)

* **Kitchen and Pantry Equipment**

* **Laundry**

* **Elevator & Motor**

* **Water Treatment Plant and Sewage/Effluent Treatment Plant**

2.2 Utility Description

2.2.1 Water-Cooled Chillers (WCH) –

A chiller is a machine that removes heat from a liquid via a vapour-compression or absorption refrigeration cycle. This liquid can then be circulated through a heat exchanger to cool equipment, or another process stream (such as air or process water). As a necessary by-product, refrigeration creates waste heat that must be exhausted to ambience, or for greater efficiency, can be recovered for heating purposes.

2.2.2 Chilled Water Pumps (CHWP)-

Chilled water pumps used to circulate the chilled water in closed loop from Higher side to low side (basically, from Water cooled chiller to Air handling units or Fan coil units).

2.2.3 Condenser Water Pumps (CDWP)-

Condenser water pumps used to circulate the condenser water in open loop from Water cooled chiller (Condenser side) to Cooling Tower for heat rejection.

2.2.4 Cooling Towers (CT's) –

A cooling tower is a heat rejection device that rejects waste heat to the atmosphere through the cooling of a water stream to a lower temperature. Cooling towers use the evaporation of water to remove process heat and cool the working fluid to near the wet-bulb air temperature.

2.2.5 Steam Boilers –

Steam boiler is a type of closed container, designed with steel for heating the water to generate steam by some energy source like burning of fuel (e.g. diesel or bio-diesel). The vapour generated will be delivered at desired pressure as per application requirement.

2.2.6 Air Handling Units (AHUs)-

An air handler, or air handling unit (often abbreviated to AHU), is a device used to regulate and circulate air as part of a heating, ventilating, and air-conditioning (HVAC) system. An air handler is usually a large metal box containing a blower, heating or cooling elements, filter racks or chambers, sound attenuators, and dampers. Air handlers usually connect to a ductwork ventilation system that distributes the conditioned air through the building and returns it to the AHU. Sometimes AHUs discharge (supply) and admit (return) air directly to and from the space served without ductwork.

2.2.7 Treated Fresh Air Units (TFAs) –

A Treated fresh air unit is basically an air handler unit which serves only fresh air rather using return air from conditioned space again. A TFA is usually a large metal box containing a blower, cooling elements, filter racks or chambers, and dampers. TFA usually connect to a ductwork ventilation system that distributes the conditioned fresh air through the building.

2.2.8 Fan Coil Units (FCUs)-

A fan coil unit (FCU) is a simple device consisting of a heating and/or cooling heat exchanger or 'coil' and fan. It is part of an HVAC system found in residential, commercial, and industrial buildings. A fan coil unit is a diverse device sometimes using ductwork, and is used to control the temperature in the space where it is installed, or serve multiple spaces. It is controlled either by a manual on/off switch or by a thermostat, which controls the throughput of water to the heat exchanger using a control valve and/or the fan speed

2.2.9 Ventilation Fans-

A mechanical fan is a powered machine used to create flow within air. A fan consists of a rotating arrangement of vanes or blades which act on the air. The rotating assembly of blades and hub is known as an impeller, a rotor, or a runner. Usually, it is contained within some form of housing or case. This may direct the airflow or increase safety by preventing objects from contacting the fan blades. All of the fans are powered by electric motors.

3. Performance Evaluation of Major Utilities and Process Equipment

The complete process of performance evaluation and testing is carried out with System Acceptance Test (SAT) or Functional Test

3.1 Water-Cooled Chillers (WCH)

ITC Grand Chola have four water-cooled chillers installed at the chiller plant room of the building. Each WCH has a capacity of 900 TR. Facility used to run chillers as per load requirement. Generally, two chillers are in working mode and rest two are in standby mode.

3.1.1 Design Specifications

The design specifications of water-cooled chillers are as follows

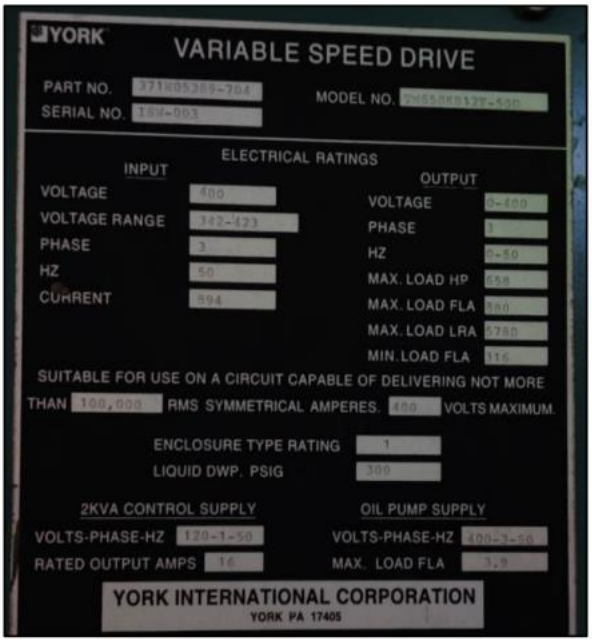


Table no -1 – Chiller 1 – Performance parameters

Water Cooled Chiller No. 1						
S. No.	Description	Design		Actual		% Deviation
		Value	UNIT	Value	UNIT	
Performance Parameters						
1	Electrical Power	511	KW	399.0	KW	-
2	Average Voltage	400	V	401.00	V	-
3	Average Current	894	A	613.00	A	-
4	Motor loading	100	%	**74**	%	-
5	Evaporator Chilled Water inlet temperature	NA	°F	52.7	°F	-
6	Evaporator Chilled Water outlet temperature	NA	°F	44.3	°F	-
7	Evaporator Chilled Water temperature difference	NA	°F	8.4	°F	-
8	Evaporator Chilled Water flow	NA	US GPM	1313.84	US GPM	-
9	Condenser Water inlet temperature	NA	°F	88.3	°F	-
10	Condenser Water outlet temperature	NA	°F	94.3	°F	-
11	Condenser Water temperature difference	NA	°F	6	°F	-
12	Condenser Water flow	NA	US GPM	2153.976	US GPM	-
13	Ambient Dry Bulb Temperature	NA	°F	83.3	°F	-
14	Ambient Wet Bulb Temperature	NA	°F	91.4	°F	-
15	Sound Level	-		84.6	dB	-
Performance Calculation						
1	Chiller Output Capacity (@100%)	900	TR	459.844	TR	-
	Chiller Output Capacity (@74%)	666	TR			
2	Chiller IKW/TR	0.57	IKW/TR	0.87	IKW/TR	53%
3	Chiller COP	6.16	COP	4.03	COP	-35%

Remarks:
1. The rest of the system's configuration during this performance testing was:
   No. of chilled water pumps running = 2
   No. of condenser water Pumps running = 2
2. The measured values were taken from Chiller data log/System status panel.

Table no -2 – Chiller 2 – Performance parameters

Water Cooled Chiller No. 2						
S. No.	Description	Design		Actual		% Deviation
		Value	UNIT	Value	UNIT	
Performance Parameters						
1	Electrical Power	511	KW	425.0	KW	-
2	Average Voltage	400	V	400.00	V	-
3	Average Current	894	A	631.33	A	-
4	Motor loading	100	%	76	%	-
5	Evaporator Chilled Water inlet temperature	NA	°F	53.6	°F	-
6	Evaporator Chilled Water outlet temperature	NA	°F	44.9	°F	-
7	Evaporator Chilled Water temperature difference	NA	°F	8.7	°F	-
8	Evaporator Chilled Water flow	NA	US GPM	1375	US GPM	-
9	Condenser Water inlet temperature	NA	°F	88.1	°F	-
10	Condenser Water outlet temperature	NA	°F	93.8	°F	-
11	Condenser Water temperature difference	NA	°F	5.7	°F	-
12	Condenser Water flow	NA	US GPM	2161.28	US GPM	-
13	Ambient Dry Bulb Temperature	NA	°F	83.3	°F	-
14	Ambient Wet Bulb Temperature	NA	°F	91.4	°F	-
15	Sound Level	-		86.3	dB	-
Performance Calculation						
1	Chiller Output Capacity (@100%)	900	TR	498.44	TR	-
	Chiller Output Capacity (@76%)	684	TR			
2	Chiller IKW/TR	0.57	IKW/TR	0.85	IKW/TR	50%
3	Chiller COP	6.16	COP	4.10	COP	-33%

Remarks:
1. The rest of the system's configuration during this performance testing was:
   No. of chilled water pumps running = 2
   No. of condenser water Pumps running = 2
2. The measured values were taken from Chiller data log/System status panel.

Table no -3 – Chiller 3 – Performance parameters

Water Cooled Chiller No. 3						
S. No.	Description	Design		Actual		% Deviation
		Value	UNIT	Value	Unit	
Performance Parameters						
1	Electrical Power	511	KW	430.0	KW	-
2	Average Voltage	400	V	404.00	V	-
3	Average Current	894	A	643.33	A	-
4	Motor loading	100	%	**78**	%	-
5	Evaporator Chilled Water inlet temperature	NA	°F	53.2	°F	-
6	Evaporator Chilled Water outlet temperature	NA	°F	44.4	°F	-
7	Evaporator Chilled Water temperature difference	NA	°F	8.8	°F	-
8	Evaporator Chilled Water flow	NA	US GPM	1475.5 84	US GPM	-
9	Condenser Water inlet temperature	NA	°F	89.1	°F	-
10	Condenser Water outlet temperature	NA	°F	96.5	°F	-
11	Condenser Water temperature difference	NA	°F	7.4	°F	-
12	Condenser Water flow	NA	US GPM	2100.6 04	US GPM	-
13	Ambient Dry Bulb Temperature	NA	°F	83.3	°F	-
14	Ambient Wet Bulb Temperature	NA	°F	91.4	°F	-
15	Sound Level	-		82.9	dB	-
Performance Calculation						
1	Chiller Output Capacity (@100%)	900	TR	541.05	TR	-
	Chiller Output Capacity (@78%)	702	TR			
2	Chiller IKW/TR	0.57	IKW/ TR	0.79	IKW/T R	40%
3	Chiller COP	6.16	COP	4.40	COP	-29%

Remarks:
1. The rest of the system's configuration during this performance testing was:
   No. of chilled water pumps running = 2
   No. of condenser water Pumps running = 2
2. The measured values were taken from Chiller data log/System status panel.

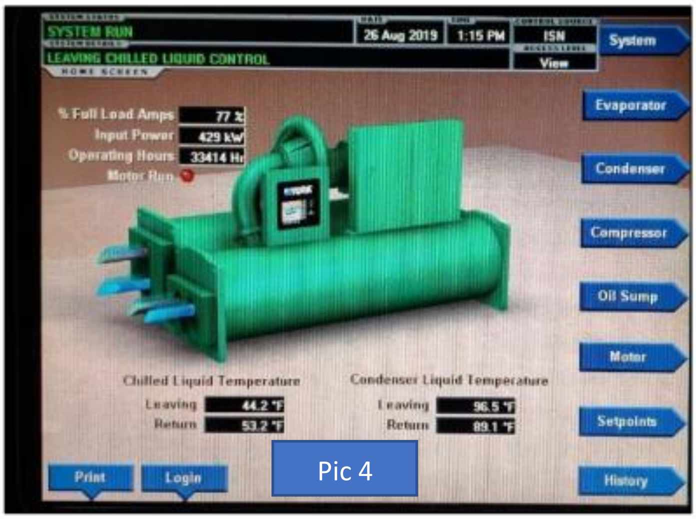
Table no -4 – Chiller 4 – Performance parameters

Water Cooled Chiller No. 4						
S. No.	Description	Design		Actual		% Deviation
		Value	Unit	Value	Unit	
Performance Parameters						
1	Electrical Power	511	KW	410.0	KW	-
2	Average Voltage	400	V	401.00	V	-
3	Average Current	894	A	626.67	A	-
4	Motor loading	100	%	**75**	%	-
5	Evaporator Chilled Water inlet temperature	NA	°F	53.8	°F	-
6	Evaporator Chilled Water outlet temperature	NA	°F	45.8	°F	-
7	Evaporator Chilled Water temperature difference	NA	°F	8.0	°F	-
8	Evaporator Chilled Water flow	NA	US GPM	1449.8	US GPM	-
9	Condenser Water inlet temperature	NA	°F	89.3	°F	-
10	Condenser Water outlet temperature	NA	°F	96.7	°F	-
11	Condenser Water temperature difference	NA	°F	7.4	°F	-
12	Condenser Water flow	NA	US GPM	2093.96	US GPM	-
13	Ambient Dry Bulb Temperature	NA	°F	83.3	°F	-
14	Ambient Wet Bulb Temperature	NA	°F	91.4	°F	-
15	Sound Level	-		83.9	dB	
Performance Calculation						
1	Chiller Output Capacity (@100%)	900	TR	483.27	TR	-
	Chiller Output Capacity (@75%)	675	TR			
2	Chiller IKW/TR	0.57	IKW/TR	0.85	IKW/TR	49%
3	Chiller COP	6.16	COP	4.13	COP	-33%

Remarks:

1. The rest of the system's configuration during this performance testing was:
   No. of chilled water pumps running = 2
   No. of condenser water Pumps running = 2
2. The measured values were taken from Chiller data log/System status panel.

Research conducted - Field measurements taken with testing and measuring instruments



Pic 1 – Sound level measurement,

Pic 2 – For chilled water flow,

Pic 3 Condenser water flow

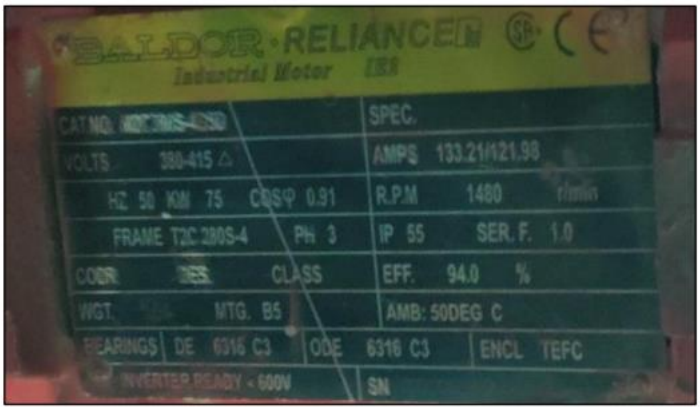
Pic 4- Chiller Automation control

3.2 Chilled Water Pumps (CHWP)

ITC Grand Chola building have four Chilled water pumps installed at chiller plant room of the building. All chilled water pumps operate on the load basis requirement as VFD is installed for each pump. Generally, out of four pumps, two pumps will be in working mode and two will be in standby mode (when configuration of chiller is same i.e. 2 no's Working+2 no's Standby).

Table No -5 – Chilled water pump - Technical parameters

Chilled Water Pump – 1	
Make	Baldor Reliance (ABB)
Capacity in kW	75 kW
Rated RPM	1480
Rated Efficiency	94.0%
Cos ψ	0.91
Chilled Water Pump – 2	
Make	Baldor Reliance (ABB)
Capacity in kW	75 kW
Rated RPM	1480
Rated Efficiency	94.0%
Cos ψ	0.91
Chilled Water Pump – 3	
Make	Baldor Reliance (ABB)
Capacity in kW	75 kW
Rated RPM	1480
Rated Efficiency	94.0%
Cos ψ	0.91
Chilled Water Pump – 4	
Make	Baldor Reliance (ABB)
Capacity in kW	75 kW
Rated RPM	1480
Rated Efficiency	94.0%
Cos ψ	0.91



Pic no 5 – Motor specifications name plate technical data

3.2.1 Testing Methodology –

The complete process of performance evaluation and testing is carried out with System Acceptance Test (SAT) or Functional Test

3.2.1.1 Table no -6 - Chilled Water Pump – 1 – performance parameters

Chilled Water Pump - 1					
S.No.	Description	Design		Actual	
		Value	UNIT	Value	UNIT
Performance Parameters					
1	**% - Running Load**	100%		90.0%	
2	Speed	1480	RPM	1386	RPM
3	Suction Pressure	-	kg/cm2	7.50	kg/cm2
4	Discharge Pressure	-	kg/cm2	8.80	kg/cm2
5	Differential Pressure across Pump	-	kg/cm2	1.30	kg/cm2
6	Input Power	75	KW	52.3	KW
7	Sound Level	-	-	84.3	dB
8	Vibration Level	-	-	2.3/4.1	mm/s

Remarks:
1. RPM measurement can't be taken due to shaft guard. Hence, noted down from IPC Panel.
2. Power input has noted down from Armstrong IPC Control Panel.
3. The measured values may have ±5% measurement error.

3.2.1.2 Table no -7 - Chilled Water Pump – 2 – performance parameters

Chilled Water Pump - 2					
S.No.	Description	Design		Actual	
		Value	UNIT	Value	UNIT
Performance Parameters					
1	**% - Running Load**	100%		89.0%	
2	Speed	1480	RPM	1380	RPM
3	Suction Pressure	-	kg/cm2	8.20	kg/cm2
4	Discharge Pressure	-	kg/cm2	9.30	kg/cm2
5	Differential Pressure across Pump	-	kg/cm2	1.10	kg/cm2
6	Input Power	75	KW	49.8	KW
7	Sound Level	-	-	82.5	dB
8	Vibration Level	-	-	2.1/3.9	mm/s

Remarks:
1. RPM measurement can't be taken due to shaft guard. Hence, noted down from IPC Panel.
2. Power input has noted down from Armstrong IPC Control Panel.
3. The measured values may have ±5% measurement error.

3.2.1.3 Table no – 8 - Chilled Water Pump – 3- Performance parameters

Chilled Water Pump - 3					
S.No.	Description	Design		Actual	
		Value	UNIT	Value	UNIT
Performance Parameters					
1	**% - Running Load**	100%		88.0%	
2	Speed	1480	RPM	1380	RPM
3	Suction Pressure	-	kg/cm2	7.80	kg/cm2
4	Discharge Pressure	-	kg/cm2	9.00	kg/cm2
5	Differential Pressure across Pump	-	kg/cm2	1.20	kg/cm2
6	Input Power	75	KW	51.1	KW
7	Sound Level	-	-	82.7	dB
8	Vibration Level	-	-	2.9/3.7	mm/s
Remarks: 1. RPM measurement can't be taken due to shaft guard. Hence, noted down from IPC Panel. 2. Power input has noted down from Armstrong IPC Control Panel. 3. The measured values may have ±5% measurement error.					

3.2.1.4 Table no -9 - Chilled Water Pump – 4 – performance parameters

Chilled Water Pump - 4					
S.No.	Description	Design		Actual	
		Value	UNIT	Value	UNIT
Performance Parameters					
1	**% - Running Load**	100%		89.0%	
2	Speed	1480	RPM	1385	RPM
3	Suction Pressure	-	kg/cm2	7.30	kg/cm2
4	Discharge Pressure	-	kg/cm2	8.50	kg/cm2
5	Differential Pressure across Pump	-	kg/cm2	1.20	kg/cm2
6	Input Power	75	KW	52.7	KW
7	Sound Level	-	-	85.1	dB
8	Vibration Level	-	-	2.9/3.9	mm/s
Remarks: 1. RPM measurement can't be taken due to shaft guard. Hence, noted down from IPC Panel. 2. Power input has noted down from Armstrong IPC Control Panel. 3. The measured values may have ±5% measurement error.					

Pic no 6 – Chilled water pump -Sound levels measurement

Pic 7 - Temperature measurement

Pic 8- Vibration levels measurement

Pic no 9 - Chiller pumps parameters in Building management system

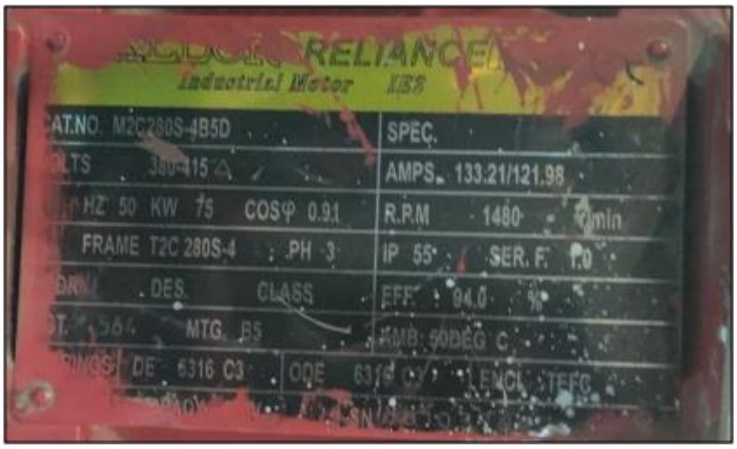
3.3 Condenser Water Pumps (CDWP)

ITC Grand Chola building have four Condenser water pumps installed at chiller plant room of the building. All Condenser water pumps operate on the load basis requirement as VFD is installed for each pump. Generally, out of four pumps, two pumps will be in working mode and two will be in standby mode (when configuration of chiller is same i.e. 2W+2S).

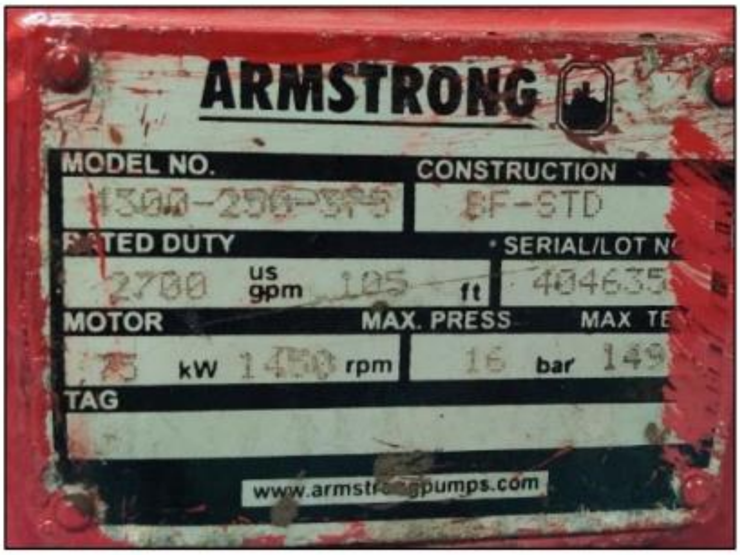
3.3.1 Design Specifications The design specifications of Condenser water pumps are as follows:

Table no -10 – Condenser water pump- Technical parameters

Condenser Water Pump – 1	
Make	Baldor Reliance (ABB)
Capacity in kW	75 kW
Rated RPM	1480
Rated Efficiency	94.0%
Cos ψ	0.91
Condenser Water Pump – 2	
Make	Baldor Reliance (ABB)
Capacity in kW	75 kW
Rated RPM	1480
Rated Efficiency	94.0%
Cos ψ	0.91
Condenser Water Pump – 3	
Make	Baldor Reliance (ABB)
Capacity in kW	75 kW
Rated RPM	1480
Rated Efficiency	94.0%
Cos ψ	0.91
Condenser Water Pump – 4	
Make	Baldor Reliance (ABB)
Capacity in kW	75 kW
Rated RPM	1480
Rated Efficiency	94.0%
Cos ψ	0.91



Pic no – 10 - Motor specification tag



Pic no – 11- Pump specification tag

Table no- 11- Condenser Water pump-1 – performance parameters

Condenser Water Pump - 1					
S.No.	Description	Design		Actual	
		Value	UNIT	Value	UNIT
Performance Parameters					
1	**% - Running Load**	100%		90.0%	
2	Speed	1480	RPM	1348	RPM
3	Suction Pressure	-	kg/cm2	4.20	kg/cm2
4	Discharge Pressure	-	kg/cm2	6.30	kg/cm2
5	Differential Pressure across Pump	-	kg/cm2	2.10	kg/cm2
6	Input Power	75	KW	61.2	KW
7	Sound Level	-	-	81.9	dB
8	Vibration Level	-	-	4.3/6.1	mm/s

Remarks:
1. RPM measurement can't be taken due to shaft guard. Hence, noted down from IPC Panel.
2. Power input has noted down from Armstrong IPC Control Panel.
3. The measured values may have ±5% measurement error.

Table no -12 - Condenser Water pump – 2 – performance parameters

Condenser Water Pump - 2					
S.No.	Description	Design		Actual	
		Value	UNIT	Value	UNIT
Performance Parameters					
1	**% - Running Load**	100%		89.4%	
2	Speed	1480	RPM	1348	RPM
3	Suction Pressure	-	kg/cm2	4.40	kg/cm2
4	Discharge Pressure	-	kg/cm2	6.50	kg/cm2
5	Differential Pressure across Pump	-	kg/cm2	2.10	kg/cm2
6	Input Power	75	KW	61.0	KW
7	Sound Level	-	-	82.5	dB
8	Vibration Level	-	-	3.9/5.2	mm/s

Remarks:
1. RPM measurement can't be taken due to shaft guard. Hence, noted down from IPC Panel.
2. Power input has noted down from Armstrong IPC Control Panel.
3. The measured values may have ±5% measurement error.

Table no -13 - Condenser Water pump – 3 – performance parameters

Condenser Water Pump - 3					
S.No.	Description	Design		Actual	
		Value	UNIT	Value	UNIT
Performance Parameters					
1	**% - Running Load**	100%		90.3%	
2	Speed	1480	RPM	1352	RPM
3	Suction Pressure	-	kg/cm2	4.20	kg/cm2
4	Discharge Pressure	-	kg/cm2	6.50	kg/cm2
5	Differential Pressure across Pump	-	kg/cm2	2.30	kg/cm2
6	Input Power	75	KW	62.5	KW
7	Sound Level	-	-	85.3	dB
8	Vibration Level	-	-	3.1/3.9	mm/s
Remarks: 1. RPM measurement can't be taken due to shaft guard. Hence, noted down from IPC Panel. 2. Power input has noted down from Armstrong IPC Control Panel. 3. The measured values may have ±5% measurement error.					

Table no 14- Condenser Water pump – 4 – performance parameters

Condenser Water Pump - 4					
S.No.	Description	Design		Actual	
		Value	UNIT	Value	UNIT
Performance Parameters					
1	**% - Running Load**	100%		88.7%	
2	Speed	1480	RPM	1341	RPM
3	Suction Pressure	-	kg/cm2	4.40	kg/cm2
4	Discharge Pressure	-	kg/cm2	6.20	kg/cm2
5	Differential Pressure across Pump	-	kg/cm2	1.80	kg/cm2
6	Input Power	75	KW	58.7	KW
7	Sound Level	-	-	84.7	dB
8	Vibration Level	-	-	3.3/4.1	mm/s
Remarks: 1. RPM measurement can't be taken due to shaft guard. Hence, noted down from IPC Panel. 2. Power input has noted down from Armstrong IPC Control Panel. 3. The measured values may have ±5% measurement error.					

3.4 Cooling towers

The unit have 4 nos cooling towers for rejection of the heat

Table no 15- Cooling Tower No -1 – Performance parameters

SAT - Cooling Tower - 1					
S.No.	Description	Design		Actual	
		Value	UNIT	Value	UNIT
Performance Parameters					
1	Inlet air temperature (DBT)	-	°F	94.1	°F
2	Inlet air temperature (WBT)	-	°F	84.3	°F
3	CT Water Inlet Temperature	-	°F	94.3	°F
4	CT Water Outlet Temperature	-	°F	88.3	°F
5	CT Fan Motor speed	-	RPM	-	RPM
Performance Calculation					
1	CT Approach	-	-	4.0	-
2	CT Range	-	-	6.0	-
3	CT Effectiveness	-	%	60.0	%
Remarks: 1. RPM measurement has not carried out due to safety concern & fan guard. 2. The measured values may have ±5% measurement error.					

Table no -15 - Cooling Tower No -2 – performance parameters

SAT - Cooling Tower - 2					
S.No.	Description	Design		Actual	
		Value	UNIT	Value	UNIT
Performance Parameters					
1	Inlet air temperature (DBT)	-	°F	94.1	°F
2	Inlet air temperature (WBT)	-	°F	84.3	°F
3	CT Water Inlet Temperature	-	°F	93.8	°F
4	CT Water Outlet Temperature	-	°F	88.1	°F
5	CT Fan Motor speed	-	RPM	-	RPM
Performance Calculation					
1	CT Approach	-	-	3.8	-
2	CT Range	-	-	5.7	-
3	CT Effectiveness	-	%	60.0	%
Remarks: 1. RPM measurement has not carried out due to safety concern & fan guard. 2. The measured values may have ±5% measurement error.					

Table no 16 - Cooling Tower No -3 – Performance parameters

SAT - Cooling Tower - 3					
S.No.	Description	Design		Actual	
		Value	UNIT	Value	UNIT
Performance Parameters					
1	Inlet air temperature (DBT)	-	°F	94.1	°F
2	Inlet air temperature (WBT)	-	°F	84.3	°F
3	CT Water Inlet Temperature	-	°F	96.5	°F
4	CT Water Outlet Temperature	-	°F	89.1	°F
5	CT Fan Motor speed	-	RPM	-	RPM
Performance Calculation					
1	CT Approach	-	-	4.8	-
2	CT Range	-	-	7.4	-
3	CT Effectiveness	-	%	60.7	%

Remarks:
1. RPM measurement has not carried out due to safety concern & fan guard.
2. The measured values may have ±5% measurement error.

Table no 17- Cooling Tower No – 4 – Performance parameters

SAT - Cooling Tower - 4					
S.No.	Description	Design		Actual	
		Value	UNIT	Value	UNIT
Performance Parameters					
1	Inlet air temperature (DBT)	-	°F	94.1	°F
2	Inlet air temperature (WBT)	-	°F	84.3	°F
3	CT Water Inlet Temperature	-	°F	96.7	°F
4	CT Water Outlet Temperature	-	°F	89.3	°F
5	CT Fan Motor speed	-	RPM	-	RPM
Performance Calculation					
1	CT Approach	-	-	5.0	-
2	CT Range	-	-	7.4	-
3	CT Effectiveness	-	%	59.7	%

Remarks:
1. RPM measurement has not carried out due to safety concern & fan guard.
2. The measured values may have ±5% measurement error.

3.5 Air Handling Units (AHUs)

The project team have installed 79 air handling units (AHUs) at ITC Grand Chola, Chennai which are serving several areas (like Banquets, Kitchens, restaurants, SPA, back-offices, Server room, laundry, etc.). Our team carried out System Acceptance Test (SAT) of some AHU's and they have been listed out as per their design capacity and serving area.

Table no -18 – Banquet AHU – Performance parameters

AHU - 8 (Rajendra Hall)									
Readings	1	2	3	4	5	6	Average Velocity (ft/min)	Area (Sq. ft.)	Air Flow (CFM)
Filter 1	670	630	490	580	525	532	571.17	34.5	19705

AHU - 8 (Rajendra Hall)			
Performance data			
Parameters		Measured Values	UNIT
Running Frequency		48	Hz
Return Air Volume		19705	CFM
Air Temp On Coil DB & WB		DB - 20.5 & WB - 17.0	°C
Air Temp Off Coil DB & WB		DB - 12.8 & WB - 12.8	°C
Delta Enthalpy		4.94	∂H
Tonnage		36.50	TR
Sound Level		74	dB
Electrical Parameters	Voltage	389	V
	Current	23.1	A

Table no -19 – SPA AHU – Performance parameters

AHU - SPA area								
Readings	1	2	3	4	5	Average Velocity (ft/min)	Area (Sq. ft.)	Air Flow (CFM)
Filter 1	460	863	638	325	550	567.2	30.0	17016

AHU - SPA area			
Performance data			
Parameters		Measured Values	UNIT
Running Frequency		49	Hz
Return Air Volume		17016	CFM
Air Temp On Coil DB & WB		DB - 28.5 & WB - 23.0	°C
Air Temp Off Coil DB & WB		DB - 16.3 & WB - 16.3	°C
Delta Enthalpy		9.52	∂H
Tonnage		60.75	TR
Sound Level		70	dB
Electrical Parameters	Voltage	402	V
	Current	22.3	A

Table no -20 – Laundry AHU – Performance parameters

AHU Laundry 5A								
Readings	1	2	3	4	5	Average Velocity (ft/min)	Area (Sq. ft.)	Air Flow (CFM)
Filter 1	221	180	380	120	320	244.2	40.37	9858

AHU - Laundry 5A			
Performance data			
Parameters		Measured Values	UNIT
Running Frequency		45	Hz
Return Air Volume		9858	CFM
Air Temp On Coil DB & WB		DB - 34.5 & WB - 24.0	°C
Air Temp Off Coil DB & WB		DB - 18.0 & WB - 18.0	°C
Delta Enthalpy		8.83	∂H
Tonnage		32.64	TR
Sound Level		82.6	dB
Electrical Parameters	Voltage	402	V
	Current	15.05	A

Table no -21 – Royal Vega AHU – Performance parameters

AHU - Royal Vega								
Readings	1	2	3	4	5	Average Velocity (ft/min)	Area (Sq. ft.)	Air Flow (CFM)
Filter 1	170	355	540	275	395	347	15.8	5483

AHU - Royal Vega			
Performance data			
Parameters		Measured Values	UNIT
Running Frequency		45	Hz
Return Air Volume		5483	CFM
Air Temp On Coil DB & WB		DB - 25.5 & WB - 19.5	°C
Air Temp Off Coil DB & WB		DB - 16.8 & WB - 16.8	°C
Delta Enthalpy		3.51	∂H
Tonnage		7.22	TR
Sound Level		71	dB
Electrical Parameters	Voltage	395	V
	Current	7.3	A

Table no -22- Lobby Lounge AHU – Performance parameters

AHU - Lobby Lounge									
Readings	1	2	3	4	5	6	Average Velocity (ft/min)	Area (Sq. ft.)	Air Flow (CFM)
Filter 1	365	630	445	490	410	345	447.5	23.12	10346

AHU - Lobby Lounge			
Performance data			
Parameters		Measured Values	UNIT
Running Frequency		35	Hz
Return Air Volume		10346	CFM
Air Temp On Coil DB & WB		DB - 23.5 & WB - 20.0	°C
Air Temp Off Coil DB & WB		DB - 14.5 & WB - 14.5	°C
Delta Enthalpy		7.12	∂H
Tonnage		27.62	TR
Sound Level		62	dB
Electrical Parameters	Voltage	394	V
	Current	8.1	A

Table no -23- Main Kitchen AHU – Performance parameters

AHU - Main Kitchen									
Readings	1	2	3	4	5	6	Average Velocity (ft/min)	Area (Sq. ft.)	Air Flow (CFM)
Filter 1	425	430	610	489	790	680	570.67	23.25	13268

AHU - Main Kitchen		
Performance data		
Parameters	Measured Values	UNIT
Running Frequency	47	Hz
Return Air Volume	13268	CFM
Air Temp On Coil DB & WB	DB - 25.0 & WB - 20.0	°C
Air Temp Off Coil DB & WB	DB - 15.0 & WB - 15.0	°C
Delta Enthalpy	6.48	∂H
Tonnage	32.24	TR
Sound Level	68	dB
Electrical Parameters – Voltage	398	V
Electrical Parameters – Current	10.1	A

Pic no 12-Field Electrical load measurements

Pic no 13- Sound level measurements

Pic no 14 Air flow measurements Pic no -15 Return air temperature with physcrometer

3.6 Treated Fresh Air Units (TFAs)

The project team have installed around 53 TFA at ITC Grand Chola, Chennai serving several areas (like Banquets, Kitchens, restaurants, SPA, back-offices, Server room, laundry, etc.). The team carried out the System Acceptance Test (SAT) of some TFA's and they have been listed out as per their design capacity and serving area.

Table no 24 – TFA Guest floor – Performance parameters

TFA - 1 Guest Floor								
Readings	1	2	3	4	5	Average Velocity (ft/min)	Area (Sq. ft.)	Air Flow (CFM)
Filter 1	395	420	370	240	350	355	14.08	4998

TFA - 1 Guest Floor			
Performance data			
Parameters		Measured Values	UNIT
Running Frequency		37	Hz
Return Air Volume		4998	CFM
Air Temp On Coil DB & WB		DB - 31.0 & WB - 25.0	°C
Air Temp Off Coil DB & WB		DB - 18.6 & WB - 18.6	°C
Delta Enthalpy		9.91	∂H
Tonnage		18.58	TR
Sound Level		76	dB
Electrical Parameters	Voltage	398	V
	Current	4.7	A

Table no -25 – Rajendra Kitchen – Performance parameters

TFA - Rajendra Kitchen								
Readings	1	2	3	4	5	Average Velocity (ft/min)	Area (Sq. ft.)	Air Flow (CFM)
Filter 1	130	190	360	225	227	226.4	38.75	8773

TFA - Rajendra Kitchen Performance data			
Parameters		Measured Values	UNIT
Running Frequency		30	Hz
Return Air Volume		8773	CFM
Air Temp On Coil DB & WB		DB - 26.5 & WB - 22.0	°C
Air Temp Off Coil DB & WB		DB - 14.2 & WB - 14.2	°C
Delta Enthalpy		10.48	∂H
Tonnage		34.48	TR
Sound Level		74	dB
Electrical Parameters	Voltage	396	V
	Current	9.2	A

Table no -26 – Main Kitchen – Performance parameters

TFA - Main Kitchen								
Readings	1	2	3	4	5	Average Velocity (ft/min)	Area (Sq. ft.)	Air Flow (CFM)
Filter 1	250	315	380	330	210	297	34.34	10199

TFA - Main Kitchen			
Performance data			
Parameters		Measured Values	UNIT
Running Frequency		40	Hz
Return Air Volume		10199	CFM
Air Temp On Coil DB & WB		DB - 27.5 & WB - 21.5	°C
Air Temp Off Coil DB & WB		DB - 14.0 & WB - 14.0	°C
Delta Enthalpy		9.89	∂H
Tonnage		37.83	TR
Sound Level		89	dB
Electrical Parameters	Voltage	400	V
	Current	12.5	A

Table no -27 – Service apartment – Performance parameters

TFA - 42 (Service Apartment)								
Readings	1	2	3	4	5	Average Velocity (ft/min)	Area (Sq. ft.)	Air Flow (CFM)
Filter 1	370	480	265	240	295	330	8.72	2878

TFA - 42 Service Apartment			
Performance data			
Parameters		Measured Values	UNIT
Running Frequency		40	Hz
Return Air Volume		2878	CFM
Air Temp On Coil DB & WB		DB - 27.0 & WB - 21.5	°C
Air Temp Off Coil DB & WB		DB - 14.9 & WB - 14.9	°C
Delta Enthalpy		8.84	∂H
Tonnage		9.54	TR
Sound Level		83.5	dB
Electrical Parameters	Voltage	398	V
	Current	3.1	A

Pic 16 Sound level measurements

Pic 17-Air flow measurements

3.7 Fan Coil Units (FCUs)-

There are total 785 fan coil units (FCUs) installed in the facility serving several spaces like EC rooms, towers wing room, service apartments, SPA, GPS, Office Areas, etc. Capacities of FCU installed here varying from 1 TR to maximum 6.3 TR. The team has listed out some FCUs for performance testing.

Table no 28- FCU Guest rooms – Performance parameters

FCU - 2620 (EC)							
Readings	1	2	3	4	Average Velocity (ft/min)	Area (Sq. ft.)	Air Flow (CFM)
Filter 1	370	515	486	423	448.5	2.01	901

FCU - 2620 (EC)		
Performance data		
Parameters	Measured Values	UNIT
Return Air Volume	901	CFM
Supply Air Temp DB & WB	DB - 24.0 & WB - 22.0	°C
Return Air Temp DB & WB	DB - 25.0 & WB - 21.0	°C
Sound Level (Trap door Open & Closed)	51 & 40	dB

Table no 29 – Tower block FCU – Performance parameters

FCU - 3806 (Tower)							
Readings	1	2	3	4	Average Velocity (ft/min)	Area (Sq. ft.)	Air Flow (CFM)
Filter 1	389	435	437	495	439	2.38	1045

FCU - 3806 (Tower)		
Performance data		
Parameters	Measured Values	UNIT
Return Air Volume	1045	CFM
Supply Air Temp DB & WB	DB - 24.0 & WB - 21.0	°C
Return Air Temp DB & WB	DB - 25.0 & WB - 21.0	°C
Sound Level (Trap door Open & Closed)	61 & 50	dB

Table no – 30- Service apartment FCU – performance parameters

FCU - 4404 (Service Apartment - I)							
Readings	1	2	3	4	Average Velocity (ft/min)	Area (Sq. ft.)	Air Flow (CFM)
Filter 1	313	320	450	263	336.5	2.38	801

FCU - 4404 (Service Apartment - I)		
Performance data		
Parameters	Measured Values	UNIT
Return Air Volume	801	CFM
Supply Air Temp DB & WB	DB - 21.0 & WB - 19.0	°C
Return Air Temp DB & WB	DB - 23.0 & WB - 20.0	°C
Sound Level (Trap door Open & Closed)	53 & 41	dB

Pic 18 -Physical inspection of FCU's

Pic 19- Sound level measurement

3.7 Ventilation Fans

ITC Grand Chola building has several ventilation fans like Supply fan, exhaust fans, fresh air fans, smoke extract fans, jet fans, pressurization fans, etc.

System Acceptance Test (SAT) or Functional Test results

Table no 31 – Kitchen exhaust fan no 1– performance parameters

Kitchen Exhaust Fan - 1				
S.No.	Description		Value	UNIT
1	Running Frequency		45	Hz
Air velocities				
1620	2050	2560	2027	2353
2	Average Velocity		2122	FPM
3	Discharge Area		13.02	SQFT
4	Measured Air Flow		27628.4	CFM
5	Vibration	Horizontal	3.80	mm/sec
6		Vertical	2.80	mm/sec
7	Sound Level		78	dB
8	Average Voltage		401	V
9	Average Current		34.1	A

Table no 32– Kitchen exhaust fan no 2 – performance parameters

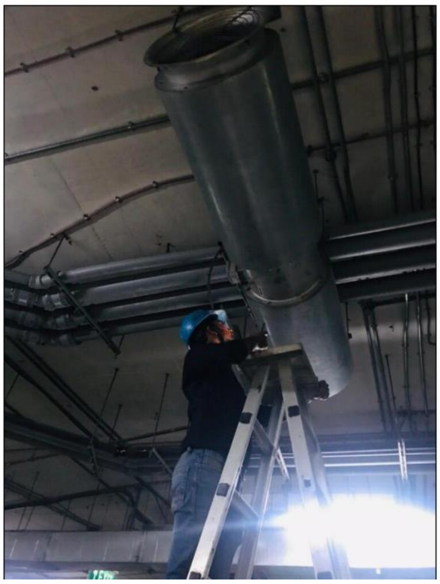
Kitchen Exhaust Fan - 2				
S.No.	Description		Value	UNIT
1	Running Frequency		40	Hz
Air velocities				
709	840	1090	960	560
2	Average Velocity		831.8	FPM
3	Discharge Area		13.02	SQFT
4	Measured Air Flow		10830.0	CFM
5	Vibration	Horizontal	3.70	mm/sec
6		Vertical	2.90	mm/sec
7	Sound Level		75	dB
8	Average Voltage		400	V
9	Average Current		31.8	A

Site measurements

Pic no 20-Vibration measurement

Pic no 21 -Sound levels measurement

Pic no 22- Air flow measurement



Pic no 23- Jet flow fan testing

4. Energy Efficiency in Utility and Process Equipment

4.1 Steam Boilers –

ITC facility has installed two steam boilers (Forbes Marshall make) in configuration of one working and one stand-by. Generally, boiler operator used to run 15 days each boiler and then next 15 days, it will get into maintenance. The existing steam boilers consumes around 1800-2000 litres of diesel per day for its operation.

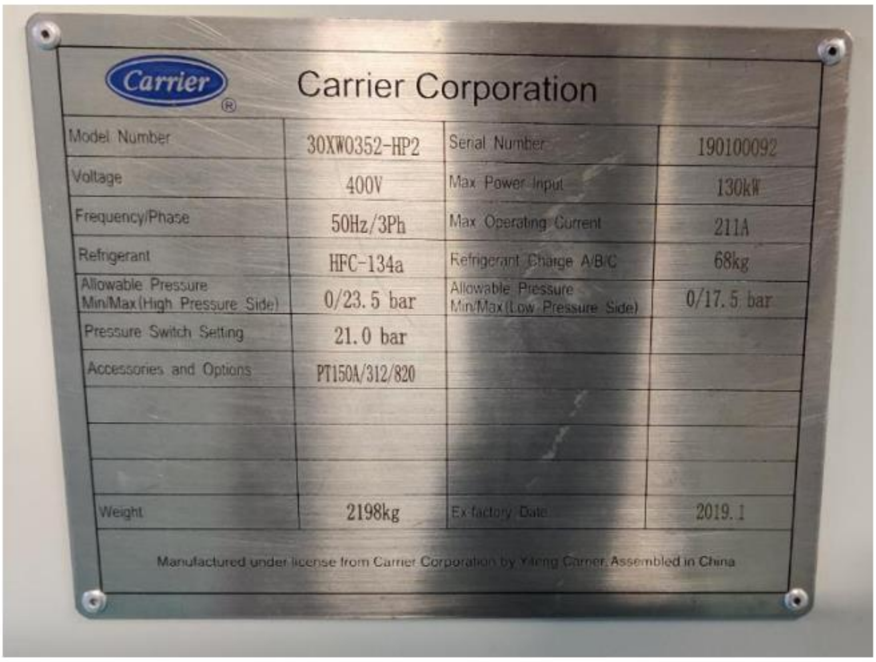
Pic no 24 -Boiler installed in facility

For supplying water from treated water tank to boiler, two feed water pumps have used in configuration of one working and one stand-by. A 3.8kL capacity of tank has installed for feeding water from tank to boiler.

Pic no 25- Surface Temperature – Varying from 61°C to 85°C

4.2 Heat Pumps

Facility has installed two heat pumps for heating up the water and distribute the same to application side. Heat pump is a refrigerant equipment which utilizes the thermal energy of the condenser cycle to produce hot water. They have two heat pumps in the configuration of one working + one standby.

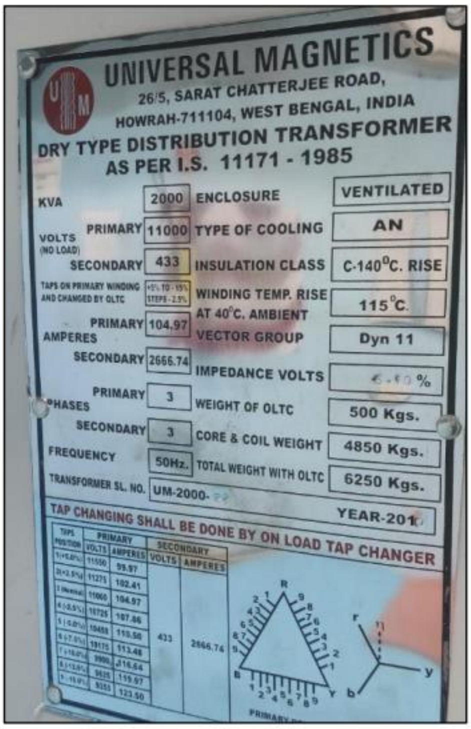


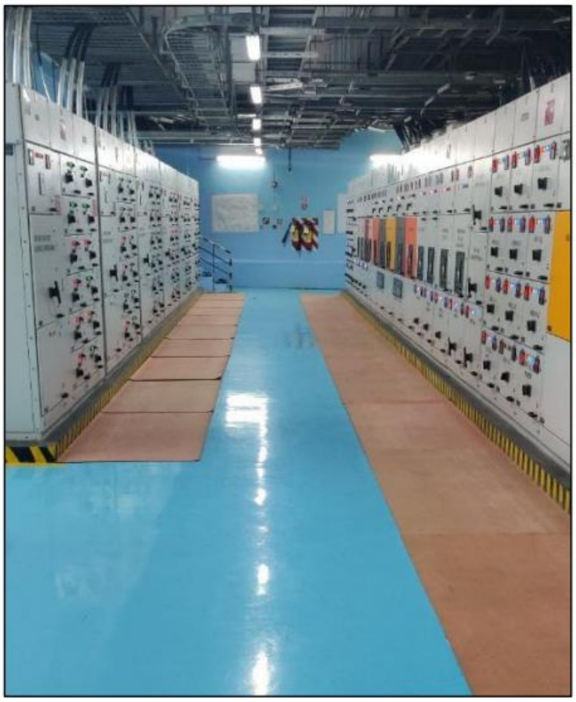
Pic no 26 – Heat pump name plate technical parameters

5.0 Electrical Systems

5.1 Transformers, HT and LT system

Electricity for the ITC Grand Chola is supplied by Tamil Nadu Generation & Distribution Corporation Limited (TANGEDCO) at 11 kV which is stepped down to 433 V. There are three dry type transformers are installed in the premises with the capacity of 2000 kVA each.





Pic no 27 -Transformer Specifications

Pic no -28 -HT and LT room

5.3.2 Automatic Power Factor Controller (Capacitor Bank)

Facility has installed capacitor bank for maintaining power factor in the building and to avoid energy losses. They have installed total 1800 kVAR capacity of capacitor banks (300 kVAR * 6). As of now, we are maintaining power factor ranging from 0.99 to 1.0 which is maintained very well

Pic no 29 -Power factor and ongoing PF

5.3.3 Uninterruptible Power Supply (UPS)-

Facility has installed UPS system for power supply in case of emergency. They have installed several UPS systems with different capacities. The Unit have 6 nos - 160 KVA capacity and 1 nos – 80 KVa capacity UPS installed in the premises.

Pic no -30 - UPS

Total 1040 kVA capacity of UPS installed in facility and 160 quantities of batteries have installed.

Pic no 31- Batteries

5.3.4 Diesel Generators (DG Sets)

ITC Grand Chola team has installed total 6150 kVA capacity of diesel generators in the configuration of 2050 kVA * 3. They are installed at DG room in engineering department zone. Facility team used to maintain data logs having data of diesel consumed and energy generated while running the DG sets. All DG's are water cooled and for same purpose, they have installed four cooling towers at terrace.

Pic no -32 – DG Sets

6. Food and Beverage Kitchen and Restaurants areas

The unit have 13 kind of restaurants serving thousands of guests on daily basis. Considering the same facility has ten numbers of kitchen for food preparation. Facility team is using LPG as primary source of energy in kitchen & pantry areas. Considering energy efficiency in kitchen section, facility has already replaced more than 70% of traditional burners to ceramic burners (Agnisumukh make) which lower down the LPG consumption of building. They have also installed dedicated LPG meter for different kitchens for tracking the LPG consumption.

Pic no -33- Agnisumukh Ceramic burner

7. Laundry

Facility has well-maintained laundry and its operation in the building. Following are the equipment's installed in the laundry-

Table no – 33- Laundry equipment's technical parameters

S. No	Description	Make	Capacity (Kg)	Power (KW)	Quantity
1	Washer Extractor	Image	200	30	2
2	Washer Extractor	Image	100	18.5	1
3	Washer Extractor	Unimac	36	7.5	1
4	Washer Extractor	Image	27	18	1
5	Washer Extractor	Image	18	2.2	1
6	Washer Extractor	LG	17	2.2	1
7	Dry Cleaning machine	Union	15	5.5	1
8	Electrical Tumbler Dryer	Image	77	120	3
9	Steam Tumbler Dryer	Image	80	7.5	2
10	Electrical Tumbler Dryer	Alliance	15	5.2	1
11	Flat work ironer	Lapauw	-	18	1
12	Electric Pressing Machine	Ramsons	-	5.5	2
13	Shirt press machine	Forenta	-	2.6	1
14	Hot head Pressing machines	Forenta	-	0	3
15	DC press machine	Forenta	-	0.1	3
16	Couff & collar press machine	Forenta	-	0.1	1
17	Foam finisher	Forenta	-	2.2	1
18	Vacuum blower		-	2.2	2
19	Spotting machine	Forenta	-	0.1	1
20	Uniform conveyor	Forenta	-	2.2	2

Average water consumption of the laundry operation is around 50 KL/day which covers around clothes weighing around 5 Ton/day. One Air handler unit, one TFA and one exhaust fan is serving in the laundry zone. Currently as on date, unit team member has replaced three nos. of traditional or steam drier with electric drier and rest two are still steam operated.

Pic no 34- Steam operated dryers

Pic no 35 Electrical energy operated dryers

8. Elevator & Motors –

The unit has installed both guest & service elevators and escalators in the building. There are around total 28 elevators & 8 escalators installed within premises which sums up to the connected load of 737 kW.

9. Water Treatment Plant (WTP)

Water treatment is any process that improves the quality of water to make it more acceptable for a specific end-use. The end use may be drinking, irrigation, water recreation or many other uses. Facility has total 9 water tanks consisting of 3 Fire tanks, 2 raw water tanks & 4 treated water tanks. Each tank having the capacity of 200 KL.

Raw water passed through the following filter section to get converted into treated water –

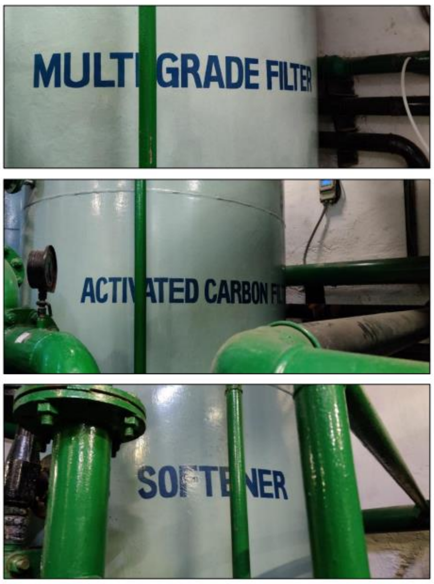
1. Multi-grade filter

2. Activated Carbon filter

3. Softener

Basically, treated water has categorized into two different zones i.e. High Zone & Low Zone. High zone serves the guest rooms whereas BOH area, kitchen, laundry, etc. have been served by low zone.

Four water distribution, pumps have installed for circulating treated water to end use & their operation is completely automated as they are maintaining pressure of 6 kg/cm2.



Pic no 36- Water Treatment plant

STP plant treats the sewage to make it fit for safe disposal, horticulture use or domestic use in toilets etc. Sewage usually contains a high quantity of organic and inorganic wastes. Here, facility has used treated water in Irrigation, Cooling Tower make-up & Flushing.

Here, facility has used treated water in Irrigation, Cooling Tower make-up & Flushing.

Pic no 37 - Sewage & Effluent Treatment Plant (STP & ETP)

Chapter 5 - Conclusion / Findings

Energy Conservation Measures (ECMs)

Following are the Energy Conservation Measures (ECMs) concluded after the detailed energy audit. The savings in kWh and cost have been analysed and accordingly the payback analysis have been performed.

11.1 ECM 1 - Nano-Thermo™ Technology Fluid (Heat Pump)

Nano-Thermo™ Technology Fluid is a patented energy saving, advanced heat transfer fluid to enhance the energy efficiency of closed loop hydronic systems. It uses nano-particles to increase the speed of energy transfer, by cooling / heating up the fluid and transferring the energy in a shorter amount of time, thereby requiring significantly less energy. It is used with water (Nano-Thermo™ Technology Fluid: water as 50:50)

Nano-Thermo™ Technology Fluid provides great benefits on environmental impacts calculated when compared to brine/water and ethylene glycol systems due to energy savings achieved during the use phase

It is best suited for closed loop heating and cooling systems. The efficiency of the system increases due to diminishing run-time of associated equipments. Hence drastic increase in equipment life is achieved along with lesser maintenance cost.

Nano-Thermo™ Technology Fluid when used with water in the ratio of 50:50 enhances the capacity of water to transfer heat. Thus, makes it more efficient in terms of energy consumption

Nano-Thermo™ Technology Fluid Applications –

This ECM can be applied to Heat Pump & Chiller System of the facility as there are closed loop system and the ROI and Investment details are listed below.

For Heat Pump:

Capacity = 122.7 x 2 kW Per day electricity consumption = 1200 kWh (Approx.)

Total Annual Energy Consumption = 1200 kWh x 365 days = 4,38,000 kWh

Considering 2.36 Rs/unit rate of energy;

Annual Cost of Energy Consumption = 4,38,000 x 2.36 = Rs. 10,33,680

Litre of Fluid Required = 450 Litre (Calculated as per pipe size)

Per Litre Cost = Rs. 1050

Installation Charges = Rs. 50,000 (Approx.)

Energy to be saved: Min 15% and up to 35%

Total Investment: (450 x 1050) + 50,000 = Rs. 5,22,500

ROI as per Nano-Thermo™ Technology Fluid Quantity: Table no -38

% of Saving	Yearly Saving	Total Saving in 5 years	Payback Period (Years)
15	1,55,052	7,75,260	3.36
20	2,06,736	10,33,680	2.52
25	2,58,420	12,92,100	2.02
30	3,10,104	15,50,520	1.68

CO_2 Emissions in 1 kWh= 0.82 kg

CO_2 Emissions reduces in 15% Savings = 0.82 Kg x 65,700 = 53,874 Kg per year

11.2 ECM 2 - Intelli-Hood:

Kitchen Ventilation Controls Melink's patented Intelli-Hood HVAC controls package visually monitors the level of cooking activity and automatically instructs the exhaust fan to operate only as fast as necessary. Intelli-Hood is installed into new or existing commercial hood systems and transforms a basic stainless-steel box into an intelligent energy-saving machine.

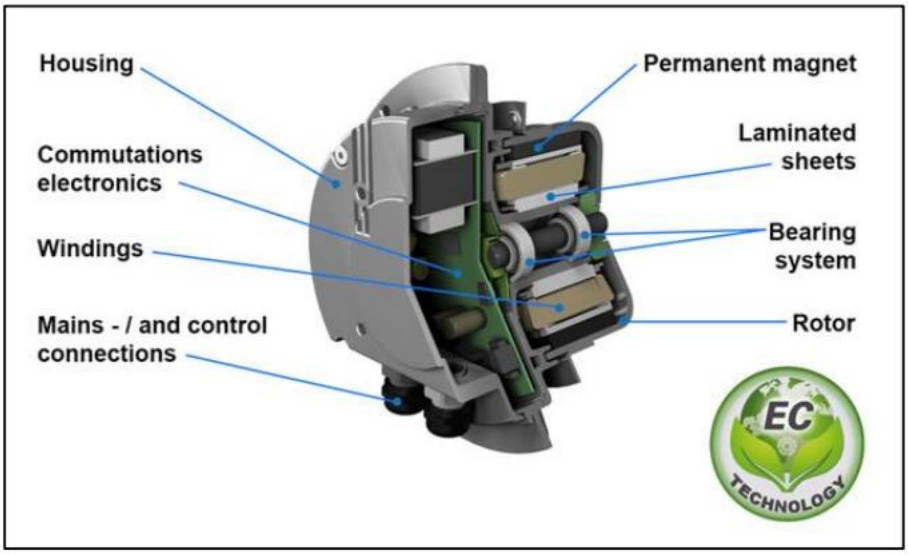
Pic no – 38 – Source – Internet - https://melinkcorp.com/kitchen-hood-controls/

Application: It can be installed in all Major Kitchens or installation can happen in phase wise in all kitchens of the facility. The payback period is around 1-2 years.

11.3 ECM 3 - EC Fans:

Energy Efficient & Environmentally Friendly EC-fans are favoured for their economical use of energy and simplification of control. EC-fans are driven by energy-saving motors with electronic control (commutation unit) ensuring optimal operating efficiency. According to their design principle, these are synchronous motors, which run without slip and therefore no slippage losses occur.

An excellent solution for demand responsive ventilation systems. Another proenvironmental aspect relevant to air supply and air conditioning equipment in particular is noise level. Here too, the advantage is with EC-motors, which run silently in controlled operating conditions. EC-motors have longer service life due to lower winding temperatures resulting in lower wear and tear.



11.3.1 Advantages with EC motors:

Up to 90 % higher efficiency than conventional systems

• Long service life due to small heat losses in the motor

• Easy to control with 0-10V DC or PWM signal

• Low sound level throughout the entire fan performance

• All control and protection electronics are integrated in the motor, easy connection

• Ventilation on demand – easy to adjust ventilation rate to actual need.

The following is included when selecting an EC motor:

• Overheat protection

• Overload protection

• Protection against locked rotor

• Control electronics

• Softstart, starts slowly and gradually increases to full speed over a predefined time.

Applications: AHU Fans, Ventilation Fans, Duct Fans, Roof Fans etc

ROI and Investment Analysis

Sample AHU – Ground Lobby (14,017 CFM, 11 kW Motor, 36.32 TR)

Power Consumed by AHU Fans with VFD = 8.8 kW

Power Consumed by EC Fans = 7.04 kW

Saving by EC Fans = 8.8 – 7.04 = 1.76 kW

Total No. of Working Hours = 24 hrs

Total No. of days per year = 365

Total Saving in kWh = 1.76 x 24 x 365 = 15,417 kWh

Considering 2.36 Rs/unit rate of energy

Total Cost Saving per year = Rs. 36,348 /-

Total Investment = Rs. 2,50,000

CO_2 Emissions in 1 kWh= 0.82 kg

CO_2 Emissions reduces = 0.82 Kg x 15,417 = 12,641 Kg per year

Payback Period

Payback Period would be approximately around 6.8 years

Note: This Analysis has been done for one AHU of Higher of CFM.

Similar, calculation will required to be done for other AHU for EC fans and prices do change system to system

11.4 ECM 4 - Enhancing or optimizing the chilled water flow in HVAC low side (AHU, TFA)

It has been recommended that the facility should optimize the chilled water flow from chillers to Air handlers & TFA's as per the load requirement. Since, facility team has already installed PICV (Pressure independent control valve) with actuators to optimize the same. Hence, it has been suggested to optimize the chilled water flow to avoid:

- Additional energy consumption of chillers & pumps.
- Excessive water flow in HVAC low side units
- Over cooling in the zone

Above issues can be resolved by adopting following measures:

- Replace or repair the faulty actuators.

- AHU Set-points has to be configured with actuator working.

11.4.1 ROI and Investment Analysis

Total running chiller load = $2 * 900 = 1{,}800\ TR$

Running chiller load (@70%) = 1260 TR

Expected savings % in kW/TR (Chiller Consumption) = 2% = 0.013 kW/TR

Reduction in load (kW) = $1260 * 0.013 = 16.38$ KW

Serving hours on annual basis = 7000 hours

Thus, total energy savings (kWh) = $16.38 * 7000 = 1{,}14{,}660/year$

Considering 2.36 Rs/unit rate of energy, the total cost saving= $1{,}14{,}660 * 2.36$

$= Rs.\ 2{,}70{,}598/year$

Thus, the project may save up to approx. Rs. 2,70,598 per year and savings in energy consumption is around up to 1,14,660 kWh/year.

CO_2 Emissions in 1 kWh= 0.82 kg CO_2

Emissions reduces = 0.82 Kg x 1,14,660 = 94,021 Kg per year

Payback Period –

Approximate investment cost for implementing suggested ECM = Rs. **1**,50,000 Payback Period would be approximately around 6-7 Months.

11.5 ECM 5 - Increasing the FCU Set-point in Guest Rooms

Guest rooms have installed with Fan Coil Units for air conditioning and thermal comfort. It has been observed that while checking-out from room or in case of non-occupied room, FCU used to run at 22°C continuously. Since, Bureau of Energy Efficiency, Ministry of Power says increasing one degree of conditioning unit can save energy up to 6%. Hence, it has been recommended to change the default set-point of FCU in guest rooms from 22°C to 23°C.

11.5.1 ROI and Investment Analysis

Total FCU's installed in Guest Rooms (Towers, EC, Suites, etc.) = 737

Total FCU load (Guest Rooms) = 1351.98 TR

Expected % savings for increasing 1°C = 5%

Reduction in load after increasing temp = $1351.98 * 5 /100 * 1$ kW = 67.59 TR

Specific Power Consumption (kW/TR) = 0.87 kW/TR

Reduction in load (kW) = $67.59 * 0.87$ = 58.80 kw

Assuming 50% of time period in a day, guest room would be unoccupied and that time FCU used to run at 22°C. Hence, serving hours on annual basis = 4,380 hours

Projected energy savings (kWh) = $58.80 * 4,380$ = 2,57,544 kWh/year

Considering 2.36 Rs/unit rate of energy, the total cost saving= $2,57,544 * 2.36$

= $Rs.$ 6,07,804/year

Thus, the project may save up to approx. Rs. 6,07,804 per year and savings in energy consumption is around up to 2,57,544 kWh/year.

CO_2 Emissions in 1 kWh= 0.82 kg

CO_2 Emissions reduces = 0.82 Kg x 2,57,544 = 2,11,186 Kg per year

Payback Period –

Approximate investment cost for implementing suggested ECM = Rs. 75,000 Payback Period would be approximately around 1.5 Month

11.6 ECM 7 - Increasing the TFA Set-point serving lobby:

It has been observed that guest lobbies are getting low temperature (around 18°C -20°C) which seems actually not required. Considering the same, it has been recommended to change (increase) the supply temperature by one degree to get around 5% savings.

ROI and Investment Analysis

Total TFA serving to guest lobby (Towers, EC, Suites, etc.) = 42

Estimated TFA load = 423 TR

Expected %-savings for increasing 1°C = 5%

Reduction in load after increasing temperature = $423 * 5/100 * 1\ kW$ = 21.15 TR

Specific Power Consumption (kW/TR) = 0.87 kW/TR

Reduction in load (kW) = $21.15 * 0.87 = 18.40\ k$w

Assuming late evening and night cycle for TFA when such temperature is not required. Hence, serving hours (10 hours/day) on annual basis = 3,650 hours

Considering 2.36 Rs/unit rate of energy, the total cost saving= $67{,}160 * 2.36$

= $Rs.\ 1{,}58{,}498/yea$r

Thus, the project may save up to approx. Rs. 1,58,498/year per year and savings in energy consumption is around up to 67,160 kWh/year.

CO_2 Emissions in 1 kWh= 0.82 kg CO_2

Emissions reduces = 0.82 Kg x 67,160 = 55,071 Kg per year

Payback Period – There will be no major investment cost for implementing suggested ECM. Still we are assuming = Rs. 50,000 Payback Period would be approximately around 3-4 Month

ECM 7 - Lighting Fixtures Replacement

Lighting is also one of the Energy Consumption area in hospitality sector and it generally ON for 24x7 in the hotels. Below are the Lighting details in ITC Grand Chola which have planned to replace in first phase.

a) No. of Lighting Fixtures in Staircases = 344

b) No. of Lighting Fixtures in Offices = 150

c) No. of Lighting Fixtures in Basements = 461

For Staircase:

Wattage of Existing CFL/ Fluorescent Lights = 28

Wattage of LED Proposed = 20

For Office:

Wattage of Existing CFL/ Fluorescent Lights = 72

Wattage of LED Proposed = 36

For Basements:

Wattage of Existing CFL/ Fluorescent Lights = 56

Wattage of LED Proposed = 28

11.8.1 ROI and Investment Analysis

Total projected energy savings (kWh) = Savings in Staircase + Savings in Office lights + Savings in Basements

= 24,108 + 16,200 + 1,13,074 kWh/year

= 1,53,382 kWh/year

Considering 2.36 Rs/unit rate of energy, the total cost saving= $1{,}53{,}382 * 2.36$

= $Rs.\ 3{,}61{,}981/year$

Thus, the project may save up to approx. Rs. 3,61,981/year and savings in energy consumption is around up to 1,53,382 kWh/year.

CO_2 Emissions in 1 kWh= 0.82 kg

CO_2 Emissions reduces = 0.82 Kg x 1,53,382 = 1,25,773 Kg per year

Payback Period –
The investment cost for implementing suggested ECM = Rs. 1,460,578

Payback Period would be approximately around 48 Months.

11.8 ECM 8 - Replacement of Steam Dryer with Electric Dryer

It has been observed that around 712 litres of diesel were using up by three number of steam dryers in the laundry services. This leads to costing of Rs.50,594/day which is very costly. Hence, it was recommended to install electric dryers in replacement of steam dryers. This replacement of electric dryers in the laundry service will save around 1,28,266 litres of diesel in 180 days.

11.8.1 Advantages of Electric Dryers:

- Operation cost is less
- Space relocation is convenient at anytime
- Require only one energy resource
- Do not require any vents
- Maintenance cost is less and easy

11.8.2 ROI and Investment Analysis

Estimated Load of 3 electric dryers = 510 kW
As the operation time is 10 hr/day, the total electricity consumption = 5100 kWh/day The projected energy savings (kWh) = = 59,63,392 kWh/year
Considering 2.36 Rs/unit rate of energy, the total cost saving= 5,963,392 $*$ 2.36
= $Rs.$ 14,073,606 /year

Thus, the project may save up to approx. Rs. 1,40,73,606/year and savings in energy consumption is around up to 59,63,392 kWh/year.
CO_2 Emissions in 1 kWh= 0.82 kg
CO_2 Emissions reduces = 0.82 Kg x 59,63,392 = 48,89,982 Kg per year

Payback Period –

The investment cost for implementing suggested ECM = Rs. 30,00,000

Payback Period would be approximately around 3 Months

11.9 ECM 9 - Replacement of Existing Boilers with Electric Boiler

Boiler is one of the major equipment in the operation of Hotel & Resorts. The steam boilers installed at the project building consumes steam in terms of 14,400 Kg /day which costs around Rs. 80,590 per day for the diesel. Because of this high cost it is recommended to replace the existing boilers with the electric boilers.

11.9.1 Advantages of Electric Boilers:

- Efficiency is high
- Maintenance cost is less and easy
- Fast steam & quandary generation
- Zero Emissions during usage
- No special health and safety precautions

11.9.2 ROI and Investment Analysis

Estimated Load of 2 electric boilers = 380 kW
As the operation time is 12 hr/day, the total electricity consumption = 9120 kWh/day Total Energy Cost per day = 9120 x 2.36 = Rs. 21,523
Cost Saving per day = Diesel Cost – Utility Cost = 80,590 – 21,523 = Rs. 59,427 / day
Total Energy Saving per day = 59,427 / 2.36 = 25,181 kWh/day
Total Projected Energy Saving per year = 25,181 x 365 = 91,91,065 kWh/year Considering 2.36 Rs/unit rate of energy, the total cost saving= 91,91,065 $*$ 2.36
$= Rs.$ 2,16,90,913 $/year$

Thus, the project may save up to approx. Rs. 2,16,90,913/year and savings in energy consumption is around up to 91,91,065 kWh/year.
CO2 Emissions in 1 kWh= 0.82 kg
CO2 Emissions reduces = 0.82 Kg x 91,91,065 = 75,36,673 Kg per year

Payback Period –
The investment cost for implementing suggested ECM = Rs. 1,28,00,000
Payback Period would be approximately around 7 Months.

11.10 ECM 10 - Replacement of Existing Burner with Agnisumukh

As a natural tendency flame and heat tend to accumulate at the centre. Agnisumukh burners regulate this natural tendency and spread the flame evenly and uniformly across the burner. The burners are flameless, smokeless and noiseless and produce uniform heat just like charcoal heat.

ITC Grand Chola team has almost upgraded their old burners to Agnisumukh Burner and getting good energy saving.

LIMITATIONS

The project has limitation in terms of executing the technology in seamless manner due to higher occupancies in the hotel. Also, there are many variables in the hotel which will impact the energy baseline while calculating the actual savings such as CDD (Cooling day degrees), higher/lower occupancies and Food and beverage covers. The sub-metering to the downstream load is practically difficult to maintain. Therefore, unit needs to take certain assumptions. The hourly meter is not available for all machines and therefore, while calculating the energy consumption, assumptions need to be taken. The instrumentations required for precise data collation are costly and therefore real time measurements over a period time is not feasible.

CHAPTER 6

SUGGESTIONS AND RECOMMENDATIONS

Energy Conservation Measures Summary & Classification of Energy

Energy Audit team has determined energy consumptions of facility in different particulars. Energy audits identify energy consumed by a facility and locate energy efficiency measures or projects. The table below depicts the Energy Efficiency/Conservation Measures (ECM or EEMs) concluded after the detailed energy audit. The description given below summarises the ECMs suggested along with their initial investment. The savings in kWh and cost has been analysed and accordingly the payback analysis has been performed.

S. No.	Description	Investment (INR)	Energy Savings/ year (kWh)	Cost Saving/ year (INR)	Payback Period (Months/ Years)	CO2 Reduction (Kgs)
1	ECM 1 – Nano-Thermo™ Technology Fluid (Heat Pumps)	5,22,500	65,700	1,55,052	12 Months	53,874
2	ECM 2 – Intelli-Hood: Kitchen Ventilation Controls	It shall depend on the no. of hoods, fans, and fan horsepower	Up to 97% in Fan Energy and 70% Conditioned Air		12-24 Months	
3	ECM 3 - EC Fans: Energy Efficient * for one fan	2,50,000	15,417	36,348	6.8 Years	12,641
4	ECM 4 - Enhancing or optimizing the chilled water flow in HVAC low side (AHU, TFA)	1,50,000	1,14,660	2,70,598	6-7 Months	94,021
5	ECM 5 - Increasing the FCU Set-point in Guest Rooms	75,000	2,57,544	6,07,804	1.5 Month	2,11,186

S. No.	Description	Investment (INR)	Energy Savings/ year (kWh)	Cost Saving/ year (INR)	Payback Period (Months/ Years)	CO2 Reduction (Kgs)
6	ECM 6- Increasing the TFA Set point Temperature serving Lobby	50,000	67,160	1,58,498	3-4 Months	55,071
7	ECM 7- Lighting Fixtures Replacement	14,60,578	1,53,382	3,61,979	48 Months	1,25,772
8	ECM 8- Replacement of Steam Dryer with Electric Dryer	30,00,000	59,63,392	1,40,73,606	3 Months	48,89,982
9	ECM 9- Replacement of Existing Boilers with Electric Boiler	1,28,00,000	91,91,065	2,16,90,825	7 Months	75,36,643
10	ECM 10 Replacement of Normal Burner to Agnisumukh	The details are given in the respective section.				

CHAPTER 7

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