T R U M P

INTERNATIONAL HOTEL & TOWER

C H I C A G O

Mechanical Technical Assignment Three
Mechanical Systems Existing Conditions Evaluation

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A EXECUTIVE SUMMARY

Trump International Hotel & Tower is a 92 story skyscraper rising over 1360' and houses of a variety of mixed use program spaces including retail, parking, a health club, hotel and condos. The total overall enclosed area will be more than 2,600,000 gross square feet, including 4 below grade levels. The primary mechanical cooling system for Trump Tower is the central refrigeration plant in Lower Level 4. Four electric centrifugal chillers provide 4,800 tons of chilled water to meet the cooling load. 25,000 GPM of Chicago River Water is pumped into the building to cool the condensers. The chilled water serves terminal fan coil units in the hotel and residential portions of the building as well as mechanical air handling units. The system schematic and further operational descriptions can be found in section B.6.

The Chicago River was a large influence in the design removing the space and energy requirement of any heat rejection equipment. Without cooling towers, Trump Tower is allowed a more architecturally refined façade and building massing. In addition it leaves more room for vegetated roofing systems. It also removes the piping required and energy consumed to pump the condenser water the 1,400' from the chiller room in LL4 to the roof.

All mechanical equipment is electric including the centrifugal chillers. Gas service is provided for restaurant service, residential cook tops, fire places, and retail kitchens in addition to an onsite diesel emergency generator located within the parking ramp helix. Heating is provided by electric resistance coils in each air handling unit as well as supplemental baseboard perimeter wall heating on all levels. The initial cost of the mechanical system including the control system, plumbing system and fire protection system is estimated to be $83,830,927 which is about $3.22 per square foot. This is estimated to be under 15% of the total estimated first cost of the building.

Many of the Energy and Atmosphere and Indoor Environmental Quality LEED credits are easily obtained. For instance, for the EA credits Fundamental Refrigerant Management and Enhanced Refrigerant Management, CFC free R-134A is specified. For IEQ credit Environmental Tomacco Smoke Control, the city of Chicago has a smoking ban. Other credits, however may be more challenging to achieve. Obtaining the LEED credit Optimize Energy Performance and its prerequisit, Minimum Energy Performance are questionable for a building with a nearly 100% glass façade such as Trump Tower and are truly dependon the design assumptions made interpreting ASHRAE standards and on the energy simulation results. Many of the credits would be easily achieved if the design engineers had planned ahead and created Measurement & Verfication plans, as well as plans for Enhanced Comissioning and Green Power.

Trump Tower utilizes several creative design solutions in the mechanical system but does not maximize potential of energy efficiency. The condenser water system takes advantage of utilizing the Chicago River to dissipate heat, but the building heating system is the archaic electric resistance. Taking advantage of several integrative design solutions and maximizing the potential of the current systems may be able to optimize energy utilization and provide a reduction in mechanical system footprint without overhauling the mechanical system design.

B MECHANICAL SYSTEM SUMMARY

B.1 DESCRIPTION

Trump International Hotel & Tower is a 92 story skyscraper rising over 1360' and houses of a variety of mixed use program spaces including retail, parking, a health club, hotel and condos. The total overall enclosed area will be more than 2,600,000 gross square feet, including 4 below grade levels. The building is divided into 7 primary occupancy zones divided by mechanical floors. Primary mechanical floors are located on Lower Level 4, Level 2, Level 15, Level 28, Level 50 and Level 90. Mechanical floors house chillers, pumps, heat exchangers, air handling units, domestic water heaters and exhaust fans for their respective vertically zoned occupancies.

A central refrigeration plant in Lower Level 4 consisting of four electric centrifugal chillers provides 4,800 tons of chilled water to meet the cooling load. Heat from the condensers is rejected to 25,000 gpm of Chicago River Water. Primary chilled water pumps circulate water through the air handling units and plate & frame heat exchangers on the lower level 4, level 28, and level 50 mechanical rooms. Secondary pumps circulate chilled water from the heat exchangers to zone air handlers and fan coil units. The supply air handling units, residential make-up air systems and various exhaust fans are zoned between each mechanical level. Heating is provided by electric resistance coils in air handling units as well as supplemental baseboard perimeter wall heating on all levels. The lobby spaces are conditioned from dedicated mechanical systems located at the mechanical level above the main lobby. Gas service is provided for restaurant service, residential cook tops, fire places, and retail kitchens in addition to an onsite diesel emergency generator located within the parking ramp helix. Dedicated pressurization systems are provided for all exit stairs and firefighting elevator lobbies. A packaged constant volume dehumidification unit is provided for the indoor pool space and health club.

B.2 DESIGN OBJECTIVES & INFLUENCES

The original mechanical design for Trump Tower was started by an MEP firm different from the engineer of record on the project. The original design engineer worked on the project for the first several years of design, but did not complete the project due to monetary disputes with the owner. The current engineer of record was not brought onto the project until after demolition teams were working to remove the building previously occupying the project site. Although many details are unknown or cannot be disclosed, the similarity of the current design documents and the original engineering design narratives provides adequate evidence that the current design engineer is completing the design for systems that have already been selected prior to their arrival on the project. The current design engineer may not be able to provide accurate reasoning as to why the original engineer on the project chose specific systems. For instance, they may not necessarily know why the electric baseboard heating was chosen over a hot water loop. Information provided by the original design engineer as to reasoning behind system selection may not be divulged because they did not finalize the current and final design.

To speed construction after the engineer had come onto the project late in the design process, the current engineer is only providing partially complete design documents to the contractor. Much of the equipment sizing, selection, and layout is being performed by the mechanical contractor and is approved by the engineer through submittals. The mechanical contractor for Trump Tower is finalizing the actually design on site. The contractor is given more authority over the design than traditional delivery methods and thus this method of delivery is being called 'design assist' by the project team. Because of this, actual system performance and overall system pricing will not be fully known until the project is completed. Any data or facts provided within this report are the comprehensive influence of numerous information sources and are to be taken only as an approximation of similar mechanical conditions to those installed in Trump International Hotel & Tower, Chicago. Due to varying assumptions and information may not necessarily be representative of the design intentions of the engineer or contractor.

The ultimate goal of the mechanical system is to maintain occupancy comfort and acceptable indoor air quality. Numerous codes and standards define acceptable comfort & quality and provide guidelines & requirements on how to maintain these conditions. It is up to the engineer to select and design an appropriate system that will provide appropriate ventilation for the anticipated occupancy as well as maintain desired humidity and temperature conditions for each interior space.

The greatest influence upon the design of the mechanical system in Trump Tower is the adjacency to the Chicago River. The high profile location provides unobstructed views of Lake Michigan and the river skyline, but most importantly serves to cool Trump Tower. Heat from the condenser is rejected into the Chicago River by means of 25,000 GPM of condenser water. This removes the need for cooling towers, allowing for a more architecturally refined building and allowing for more space for a vegetated roof. It also removes the piping required and energy consumed to pump the condenser water the 1,4000' from the chiller room in LL4 to the roof.

B.3 ENERGY SOURCES & RATES

In the time since publishing Technical Report 2, more detailed utility rate structures have been disclosed from the engineer. The current rate structures do not account for future rate increases and are provided in Table 1. All primary mechanical equipment in Trump Tower is electric including the centrifugal chillers, air handling units, reheat coils, baseboard heating, pumps, and dehumidification equipment. Heat from the chiller condensers is dissipated into the Chicago River.

Table 1 (Continued on Next Page): Utility Rate Structures

Com Ed Electric Utility Rate Structure							
Location	Description	Customer Charge	Tax	Demand Charge		Consumption Charge	
Tower, Hotel, Health Club & Ammenities	Large General Service	$524.61	9.60%	October - April		October - April	
				< 10,000 kW	$12.85/kW	Peak	$0.05/kWh
				> 10,000 kW	$5.030/kW	Non Peak	$0.021/kWh
				May-September		May-September	
				< 10,000 kW	$16.41/kW	Peak	$0.05/kWh
				> 10,000 kW	$6.51/kW	Non Peak	$0.021/kWh

Table 1 (Continued from Last Page): Utility Rate Structures

Location	Description	Customer Charge	Tax	Demand Charge	Consumption Charge	
Residential	Residential Service	$2.94	8.90%	October - April	October - April	
				-	< 400 kWh	$0.083/kWh
				-	> 400 kWh	$0.062/kWh
				May-September	May-September	
				-	< 400 kWh	$0.083/kWh
				-	> 400 kWh	$0.083/kWh

Other Utility Rate Structures

Chilled Water		Gas (Includes Delivery & Tax)	Domestic Water & Sewage Rate
Capacity Charge	$210/ton-yr	None	None
Usage Charge	$0.18/ton-hr	$1.05/Therm	$2.43/1000 gallons

B.4 DESIGN AIR CONDITIONS

Table 2 summarizes the outdoor design conditions in which the mechanical system must be able to operate. Table 3 summarizes the indoor conditions the HVAC system must be able to maintain.

Table 2: Outdoor Design Conditions

Season	Condition
Winter	-10 °F
Summer	94°F DB, 76°F WB

Table 3: Indoor Design Conditions

Space Occupancy	Temperature		Humidity	
	Summer	Winter	Summer	Winter
Office Areas	75°F	75°F	50%	-
Condominium Areas	76°F	72°F	50%	-
Lobbies, Public Spaces	80°F	70°F	50%	-
Elevator Equipment Room	85°F	65°F	-	-
Indoor Pool	85	82°F	55%	55%
Health Club	80°F	78°F	55%	55%
Telephone Equipment	95°F	-	-	-
Parking	Ventilated	45°F	-	-
Mechanical Rooms	Ventilated	65°F	-	-

B.5 MAJOR SYSTEM EQUIPMENT SUMMARY TABLES

Tables 4-12 summarize the major mechanical equipment for the mechanical system of Trump Tower.

Table 4: Chiller Schedule

Tag	Capacity	Type	Refrigerant	kW/ton	FLA	Evaporator				Condenser				
						GPM	EWT	LWT	Max PD (ft)	Fluid	GPM	EWT	LWT	Max PD (ft)
CHLR-LL4.1	1175	Centrifugal	HFC-134a	0.589	1031	4500	43.20°F	37.00°F	25	River Water	5000	79.00°F	85.55°F	15
CHLR-LL4.2	1225	Centrifugal	HFC-134a	0.589	1085	4500	49.70°F	43.20°F	25	River Water	5000	85.60°F	92.33°F	15
CHLR-LL4.3	1175	Centrifugal	HFC-134a	0.589	1031	4500	43.20°F	37.00°F	25	River Water	5000	79.00°F	85.55°F	15
CHLR-LL4.4	1225	Centrifugal	HFC-134a	0.589	1085	4500	49.70°F	43.20°F	25	River Water	5000	85.60°F	92.33°F	15

Table 5: Air Handling Unit Fan Schedule

Tag	Service	Total CFM	Min. OA	Ext SP	Fan Type	RPM	HP	BHP
AHU-M1.1	Lobby, Retail & Circulation	110,000	20,000	5	AF DWDI		2 @ 125	106.7
AHU-M1.2	Lobby, Retail & Circulation	110,000	20,000	5	AFDWDI		2 @ 125	106.7
AHU-M1.3	Chiller Room	8,000	4,000	3	AF		7 1/2	5.8
AHU-M2.1	Health Club And Night Spa	60,000	19,800	3.2	AF SWSI	1620	2 @ 60	115
AHU-M2.2	Hotel Amenities	100,000	20,000	5	AF DWDI		2 @ 100	97
AHU-M2.3	Kitchen	To be Determined by Mechanical Contractor						
AHU-M3.1	Hotel Corridor Make Up	28,200	28,200	2	AF SWSI PL	1044	40	29.91
AHU-M3.2	Hotel Corridor Make Up	28,200	28,200	2	AF SWSI PL	1044	40	29.91
AHU-M3.3	Condo Corr. Supply (29-40)	25,200	25,200	3.5	AF SWSI PL	1317	40	36.61
AHU-M3.4	Condo Corr. Supply (29-40)	25,200	25,200	3.5	AF SWSI PL	1317	40	36.61
AHU-M3.5	Water Heater Room	5,000	5,000	0.4	FC	1350	5	3.43
AHU-M4.1	Condo Corr. Supply (41-65)	43,100	43,100	3.5	AF SWSI PL	816	75	60.72
AHU-M4.2	Condo Corr. Supply (29-40)	43,100	43,100	3.5	AF SWSI PL	816	75	60.72
AHU-M4.3	Water Heater Room	3,000	3,000	0.4	FC	1350	3	2.06
AHU-M5.1	Condo Corr. Supply (66-85)	21,600	21,600	3.5	AF SWSI PL	1261	40	31.51
AHU-M5.2	Condo Corr. Supply (29-40)	21,600	21,600	3.5	AF SWSI PL	1261	40	31.51
AHU-M5.3	Water Heater Room	3,000	3,000	0.4	FC	1350	3	1.03

Table 6: Chilled Water Coil Schedule

Tag	Location	CFM	Max Face Vel (FPM)	Entering Air Temperature		Leaving Air Temperature		Max PD (in)	Capacity (MBH)		Fluid Data		Max PD (ft)	EWT (°F)	LWT (°F)
				DB	WB	DB	WB		Total	Sensible	Type	GPM			
CC-M1.1	AHU-M1.1	110,000	550	78.6	64.8	49.7	49.7	1.59	4299.3	3644	25% PG	566	30	40	55.9
CC-M1.2	AHU-M1.2	110,000	550	78.6	64.8	49.4	49.4	1.57	4299.3	3644	25% PG	566	30	40	55.9
CC-M1.3	AHU-M1.3	8,000	550	85	68.8	52	51.9	0.75	392.1	293.7	25% PG	52	30	40	56
CC-M2.1	AHU-M2.1	60,000	550	81.6	66.6	49.4	49.4	1.5	3027.6	2140	25% PG	350	30	42	60.1
CC-M2.2	AHU-M2.2	100,000	550	81.3	66.4	49.5	49.5	1.59	3647.6	2820.3	25% PG	480	30	40	55.9
CC-M3.1	AHU-M3.1	28,200	550	95	75	53	52.7	0.83	2120.6	1346.1	Water	263.5	30	43.3	59.4
CC-M3.2	AHU-M3.2	28,200	550	95	75	53	52.7	0.83	2120.6	1346.1	Water	263.5	30	43.3	59.4
CC-M3.3	AHU-M3.3	25,200	550	95	75	53.5	53.2	0.91	1863.4	1187.9	Water	231.5	30	43.3	59.4
CC-M3.4	AHU-M3.4	25,200	550	95	75	53.5	53.2	0.91	1863.4	1187.9	Water	231.5	30	43.3	59.4
CC-M4.1	AHU-M4.1	43,100	550	95	75	53.1	52.8	0.59	3244.1	2055.4	Water	403	30	43.5	59.6
CC-M4.2	AHU-M4.2	43,100	550	95	75	53.1	52.8	0.59	3244.1	2055.4	Water	403	30	43.5	59.6
CC-M5.1	AHU-M5.1	21,600	550	95	75	53.8	53.5	0.66	1580.3	1009.8	Water	197	30	43.5	59.5
CC-M5.2	AHU-M5.2	21,600	550	95	75	53.8	53.5	0.66	1580.3	1009.8	Water	197	30	43.5	59.5

Table 7: Electric Humidifier Schedule

Tag	Location	CFM	Steam LBS/HR	kW
H-M3.1	AHU-M3.3	28,200	285	100
H-M3.2	AHU-M3.4	28,200	285	100
H-M3.3	AHU-M3.1	25,200	285	100
H-M3.1	AHU-M3.2	25,200	285	100
H-M4.1	AHU-M4.1	43,100	(2) @ 285	(2) @ 100
H-M4.1	AHU-M4.2	43,100	(2) @ 285	(2) @ 100
H-M5.1	AHU-M5.1	21,600	285	100
H-M5.2	AHU-M5.2	21,600	285	100

Table 8: Pump Schedule

Tag	Type	Service	GPM	Head (ft)	Duty/ Standby	Motor Data			
						Max BHP	HP	RPM	VFD
CWP-LL2.1	Vertical Turbine	Condenser River Water	7500	45	Duty	124.9	150	653	Yes
CWP-LL2.2	Vertical Turbine	Condenser River Water	7500	45	Duty	124.9	150	653	Yes
CWP-LL4.1	Horizontal Split Case	Condenser River Water	5000	75	Duty	138.8	150	880	No
CWP-LL4.2	Horizontal Split Case	Condenser River Water	5000	75	Duty	138.8	150	880	No
CWP-LL4.3	Horizontal Split Case	Condenser River Water	5000	75	Standby	138.8	150	880	Yes
CHWP-LL4.1	Horizontal Split Case	Primary Chilled Water	4500	175	Duty	279.1	300	1750	Yes
CHWP-LL4.2	Horizontal Split Case	Primary Chilled Water	4500	175	Duty	279.1	300	1750	Yes
CHWP-LL4.3	Horizontal Split Case	Primary Chilled Water	4500	160	Standby	279.1	300	1750	Yes
CHWP-LL4.4	Horizontal Split Case	Secondary Chilled Water Hotel	2225	160	Duty	136.3	150	1750	Yes
CHWP-LL4.5	Horizontal Split Case	Secondary Chilled Water Hotel	2225	160	Duty	136.3	150	1750	Yes
CHWP-M3.1	Horizontal Split Case	Secondary Chilled Water Lower Condo	1540	160	Duty	91.2	100	1750	Yes
CHWP-M3.2	Horizontal Split Case	Secondary Chilled Water Lower Condo	1540	160	Duty	91.2	100	1750	Yes
CHWP-M4.1	Horizontal Split Case	Secondary Chilled Water Upper Condo	2100	165	Duty	128.2	150	1750	Yes
CHWP-M4.2	Horizontal Split Case	Secondary Chilled Water Upper Condo	2100	165	Duty	128.2	150	1750	Yes
P-LL2.1	Multistage Centrifugal	Traveling Water Screen Spray Piping	140	195	Duty	10.6	15	3450	No
P-LL2.2	Multistage Centrifugal	Traveling Water Screen Spray Piping	140	195	Duty	10.6	15	3450	No

Table 9: Heat Exchanger Schedule

Tag	Service	Capacity (MBH)	Working Pressure (psi)	Dimensions				Hot Side					Cold Side				
				Diam.	Length	Width	Height	Flow Rate (GPM)	EWT (° F)	LWT (° F)	Pressure Drop	Fluid	Flow Rate (GPM)	EWT (° F)	LWT (° F)	Pressure Drop	Fluid
HX-LL4.1	Primary CHW/ Hotel CHW	14070	450	10"	157"	37"	114"	2225	53	40.0	9.95"	25% PG	2147	37	50	7.88'	Water
HX-LL4.2	Primary CHW/ Hotel CHW	14070	450	10"	157"	37"	114"	2225	53	40.0	9.95"	25% PG	2147	37	50	7.88'	Water
HX-M3.1	Primary CHW/ Lower Condo CHW	7509	325	10"	86"	37"	114"	1540	53	43.3	9.86"	Water	1145	37	50	5.73'	Water
HX-M3.2	Primary CHW/ Lower Condo CHW	7509	325	10"	86"	37"	114"	1540	53	43.3	9.86"	Water	1145	37	50	5.73'	Water
HX-M4.1	Primary CHW/ Upper Condo CHW	10030	325	10"	86"	37"	114"	2100	53	43.5	9.89"	Water	1533	37	50	5.56'	Water
HX-M4.2	Primary CHW/ Upper Condo CHW	10030	325	10"	86"	37"	114"	2100	53	43.5	9.89"	Water	1533	37	50	5.56'	Water

Table 10: Fan Coil Unit Schedule

Tag	Location	Fan/Motor Data				Cooling Coil Data										Heating Coil Data			
		CFM	ESP (in)	HP	Voltage	Total BTUH	Sensible BTUH	GPM	WPD (ft)	EWT (° F)	LWT (° F)	DB EAT	WB EAT	DB LAT	WB LAT	kW	Voltage	EAT (° F)	LAT (° F)
FCU-3	Hotel	300	0.15	1/3	208	8200	7070	1.2	7.9	41	55	76	63	54	53.7	2	208	72	31.1
FCU-4A	Hotel	420	0.25	1/3	208	9400	9400	1.3	1.7	41	55	76	63	56.6	55.8	2	208	72	84.2
FCU-4B	Hotel	310	0.25	1/3	208	8100	7100	1.2	1.3	41	55	76	63	53.9	53.6	1.5	208	72	86
FCU-6A	Hotel	545	0.25	1/3	208	15750	13700	2.3	6.5	41	55	76	63	53.6	53.1	2.5	208	72	87
FCU-6B	Hotel	805	0.25	1/3	208	19700	17400	2.6	10	41	55	76	63	56.2	54.7	3.5	208	72	87
FCU-8A	Hotel	840	0.25	1/3	208	20100	18700	3	10.6	41	55	76	63	55.5	54.2	4	208	72	87
FCU-8B	Hotel	940	0.25	1/3	208	21670	19220	3.2	12.9	41	55	76	63	57.3	55.2	4.5	208	72	87
FCU-12	Hotel/ Tower	1150	0		208	24680	23368	4.5	4	41	55	76	63	56.9	55.2	-	-	-	-
FCU-3	Residences	300	0.15	1/3	208	9510	7615	1.7	9.2	43.5	57.5	76	63	53.2	52.5	2	208	70	91.1
FCU-4	Residences	445	0.25	1/3	208	12704	10650	1.8	2.7	43.5	57.5	76	63	54.1	53.1	2	208	70	84.2
FCU-4B	Residences	300	0.25	1/3	208	8740	7130	1.2	5.3	43.5	57.5	76	63	52.8	51.9	2	208	70	91.1
FCU-8	Residences	940	0.25	1/3	208	23820	20100	3.4	12.6	43.5	57.5	76	63	55.5	54.2	4.5	208	70	85
FCU-8A	Residences	520	0.25	1/3	208	17820	13965	2.5	7	43.5	57.5	76	63	55.5	54.2	4	208	70	85
FCU-8B	Residences	840	0.25	1/3	208	19760	18150	3.2	11.1	43.5	57.5	76	63	57.3	55.2	4	208	70	87
FCU-8C	Residences	630	0.25	1/3	208	15590	14330	2.6	7.3	43.5	57.5	76	63	55.3	54.4	3	208	70	85
FCU-12	Residences/ Tower	1150	0		208	37000	29300	4.5	3.5	43.5	57.5	76	63	55.7	54.1	-	-	-	-
FCU-800	Residences	800	0.4		240	24300	17800	6.5	11	42	56	76	63	55	54	4	240	70	85
FCU-1200	Residences	1200	0.4		240	34100	25700	8	7.9	42	56	76	63	55	54	8	240	70	85
FCU-1600	Residences	1600	0.4		240	47100	35200	10	7.9	42	56	76	63	55	54	8	240	70	85
FCU-2000	Residences	2000	0.4		240	56200	42400	13	12.5	42	56	76	63	55	54	10	240	70	85

Table 11: Electric Baseboard Heat Schedule

Tag	Location	Type	Watts Per Foot	Length	Height	Depth	Volts
EBB-150	Various	Floor Mount	150	48	6	3 5/8	208
EBB-250A	Various	Floor Mount	250	48	6	3 5/8	208
EBB-250B	Lobby	Through	250	48	6	12	208
EBB-300	Various	Floor Mount	300	48	6	3 5/8	208
EBB-500A	Various	Floor Mount	500	48	6	3 5/8	208
EBB-500B	Lobby	Through	500	48	6	12	208
EBB-600	Various	Floor Mount	600	48	6	3 5/8	208

Table 12: Parking Garage Exhaust Fan Schedule

Tag	Location	Type	CFM	Total SP	BHP	HP	Drive	Max RPM	Volts
EF-LL3.1	LL3	Prop	9,000	0.5		3	Belt	564	480
EF-LL2.1	LL2	Prop	16,000	0.3		5	Belt	357	480
EF-LL1.1	LL1	Centrifugal Inline	17,000	0.3	4.5	7 1/2	Belt	720	480
EF-3.1-3.4	L3	Prop	8,750	0.25	929	1 1\4	Belt	899	460
EF-4.1-4.4	L4	Prop	8,750	0.25	929	1 1\4	Belt	899	460
EF-5.1-5.4	L5	Prop	8,750	0.25	929	1 1\4	Belt	899	460
EF-6.1-6.4	L6	Prop	8,750	0.25	929	1 1\4	Belt	899	460
EF-7.1-7.4	L7	Prop	8,750	0.25	929	1 1\4	Belt	899	460
EF-8.1-8.4	L8	Prop	8,750	0.25	929	1 1\4	Belt	899	460
EF-9.1-9.4	L9	Prop	8,750	0.25	929	1 1\4	Belt	899	460
EF-10.1-10.4	L10	Prop	8,750	0.25	929	1 1\4	Belt	899	460
EF-11.1-11.4	L11	Prop	8,750	0.25	929	1 1\4	Belt	899	460
EF-12.1-12.4	L12	Prop	8,750	0.25	929	1 1\4	Belt	899	460

B.6 System Schematic & Operation

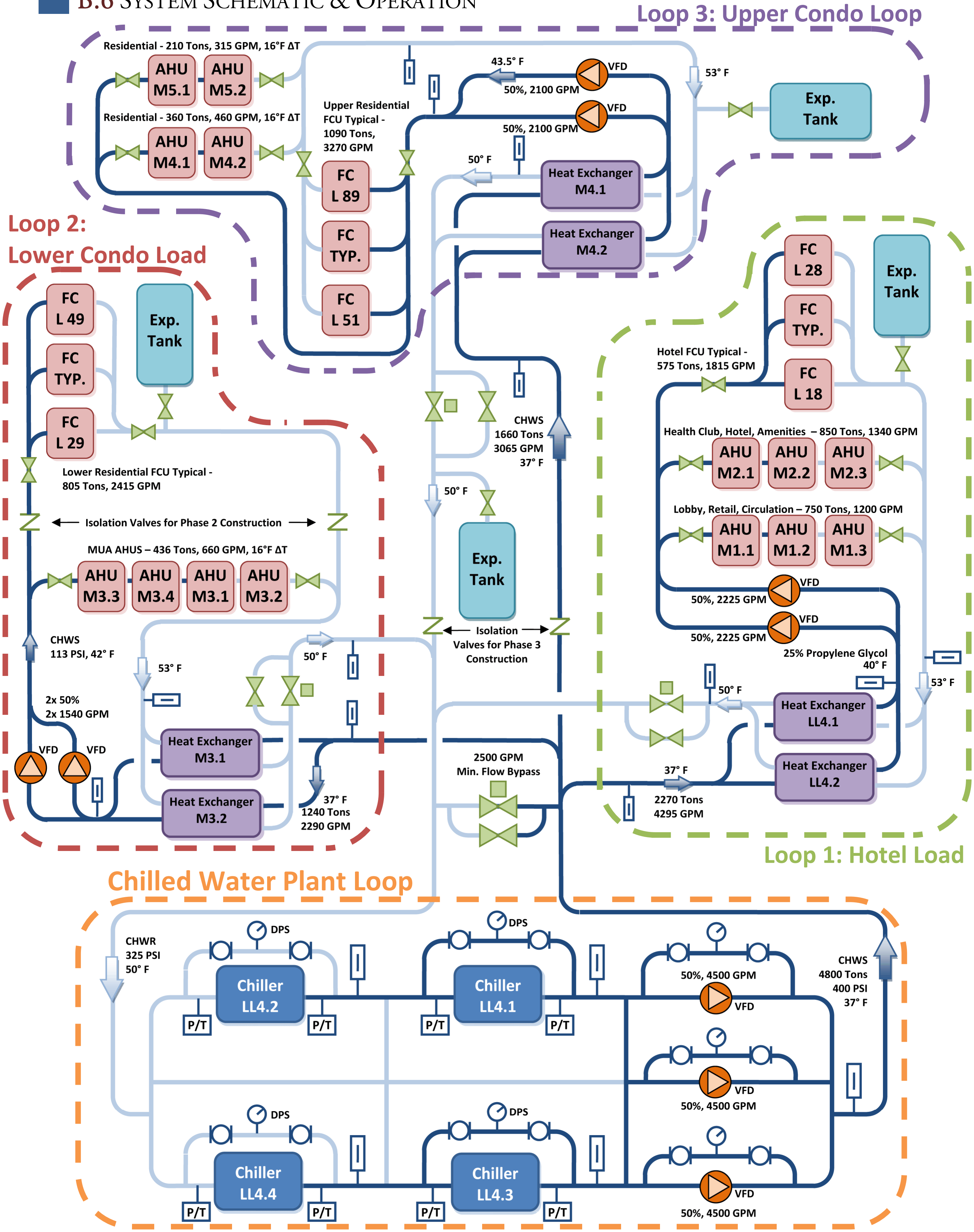

Figure 1: Chilled Water System Schematic (Note: Best Viewed in Color)

Figure 1 simplifies the chilled water system into a flow diagram. Trump Tower has a central refrigeration plant on Lower Level 4 where four electric centrifugal chillers operate in series to provide a maximum of 4800 tons of chilled water. When called for cooling, primary chilled water pumps will begin circulating 37°F chilled water through the air handling units and plate & frame heat exchangers on the lower level 4, level 28, and level 50 to maintain the supply setpoint temperature. Two of the three primary chilled water pumps will alternate running at 50% of the load requirements to maximize the life span of the pumps, and a bypass control valve will modulate to maintain the minimum flow of 2500 GPM flow as required through the chillers. Secondary chilled water pumps will circulate chilled water from the heat exchangers to zone air handling and terminal fan coil units. The supply air handling units, residential terminal fan coil units and various exhaust fans are vertically zoned between each mechanical level. During unoccupied periods, valves at each air handling unit will be commanded shut.

There are three main secondary loops: The hotel loop, the lower residential loop and the upper residential loop. The heat exchangers for the hotel loop are located on lower level 4. The 37°F primary chilled water enters the heat exchangers from the plant loop and cools a 25% propylene glycol solution to 40°F. The 40°F propylene glycol solution is then pumped through the air handling units serving the retail, health club, corridors & restaurant spaces as well as the fan coil units serving the hotel. As the 40°F propylene glycol solution cools these spaces, it absorbs heat. Each air handling unit cooling coil valve will modulate to maintain an outlet coil temperature of 53°F to return to the heat exchangers and the control valves for the primary chilled water loop will modulate to maintain a 50°F chilled water return temperature to the chillers.

The two residential loops are served by heat exchangers on upper mechanical floors. The lower residential loop is served by heat exchangers on the mechanical level 28. When called for cooling, 37°F primary chilled water cools secondary chilled water to 42°F. The 42°F secondary chilled water is then pumped through fan coil units that serve the residential condos as well as air handling units which serve the circulation spaces. Similarly, the upper residential loop is served by heat exchangers on the mechanical level 50, where the 37°F primary chilled water cools secondary chilled water to 43.5°F. This 43.5°F chilled water serves the upper residential fan coil units as well as the circulation air handling units. Again, each air handling unit cooling coil valve will modulate to maintain an outlet coil temperature of 53°F to return to the heat exchangers and the control valves for the primary chilled water loop will modulate to maintain a 50°F chilled water return temperature to the chillers.

When called for heating, electric coils located at the inlet plenum of the air handling units and fan coil units will modulate to maintain the discharge air temperature setpoint. Where applicable, if the preheat air handling coil is fully energized, the electric reheat coil will modulate to maintain the discharge air temperature setpoint. In the residential units electric baseboard heat will initiate together with the electric coil in the terminal unit and will be controlled by the fan coil unit thermostat. Electric baseboard heating in public circulation spaces other than the lobby will be controlled by the local zone thermostat. For the lobby space, electric baseboard heating will modulate inversely with the change in outdoor temperature and is designed to compensate for weather conditions such as wind and rain as well as a service voltage reduction. Outside air sensors to measure temperature and humidity will be located at three different locations on the exterior of the building to determine the average global outside air conditions. One pair of sensors will be located at the lower mechanical floor, one pair on the third mechanical floor, level 50 and the third pair on the upper mechanical floor, level 90.

Water from the Chicago River is pumped into Trump Tower by two vertical turbine condenser water pumps and used to cool the condensers on each of the centrifugal chillers. Traveling water screens and basket strainers with pressure differential pressure sensors ensure clean water entering the condenser water system. If the differential pressure exceeds the setpoint of 3 psi, an alarm will alert the operator that the screen and strainer need to be cleaned. The water temperature is measured and the condenser water mixing valves modulate to maintain temperature as required by the chiller to provide condenser cooling for the varying load. The two primary condenser water pumps will operate continuously and will modulate to maintain a river discharge flow greater than the return from the chiller loop as sensed by the flow meters. In addition, temperature alarms will notify control valves to ensure a minimum68°F setpoint to the chillers and maximum 60 °F winter discharge to the river. In the event that the discharge temperature rises above 60°F to the river, the VFD of the primary condenser water pump will increase to lower the river water discharge temperature. Two of the three secondary condenser water chiller loop pumps will alternate running at 50% of the load requirements to maximize the life span of the pumps. Figure 2 provides a simplified condenser water system flow diagram schematic.

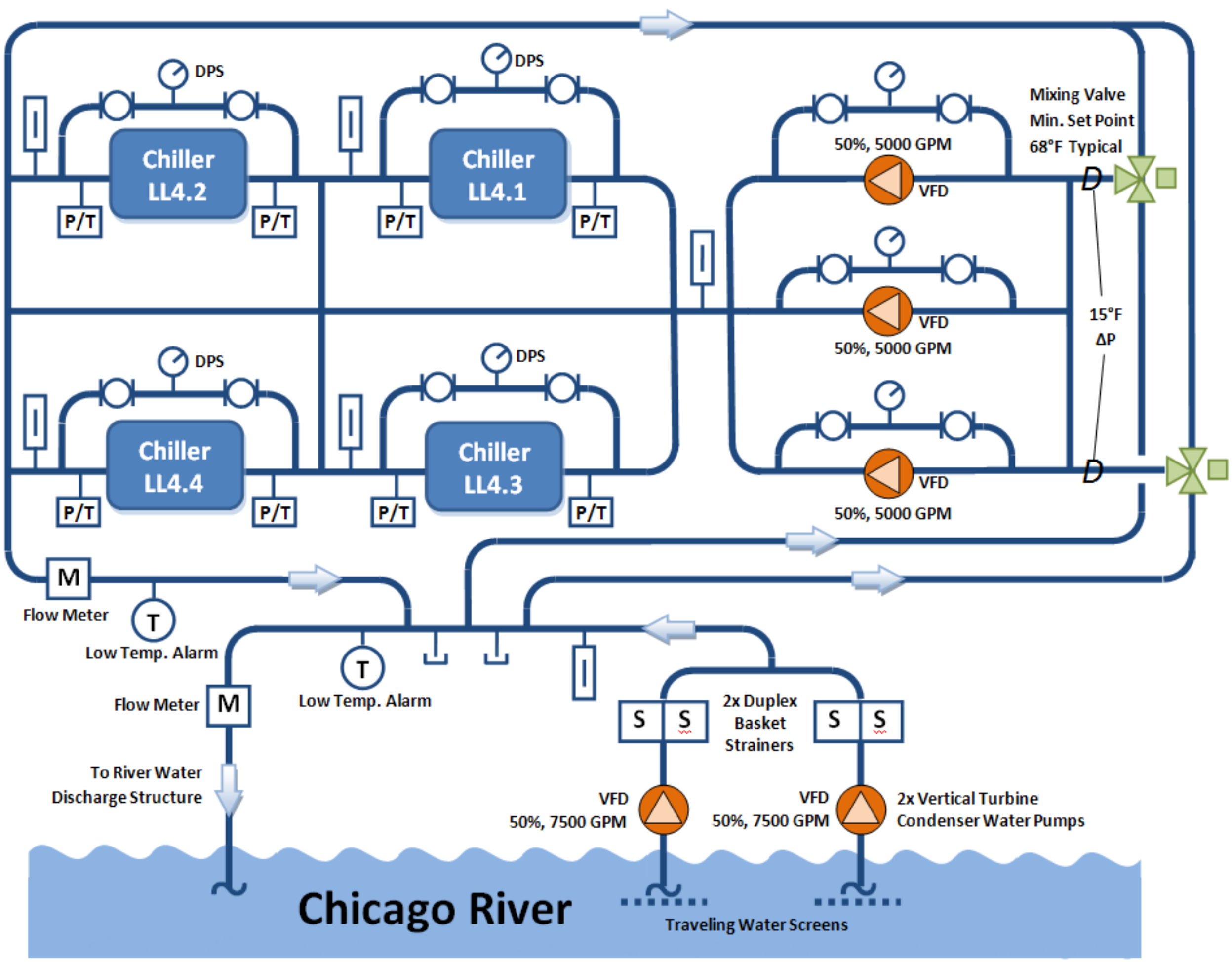

Figure 2: Condenser Water System Schematic

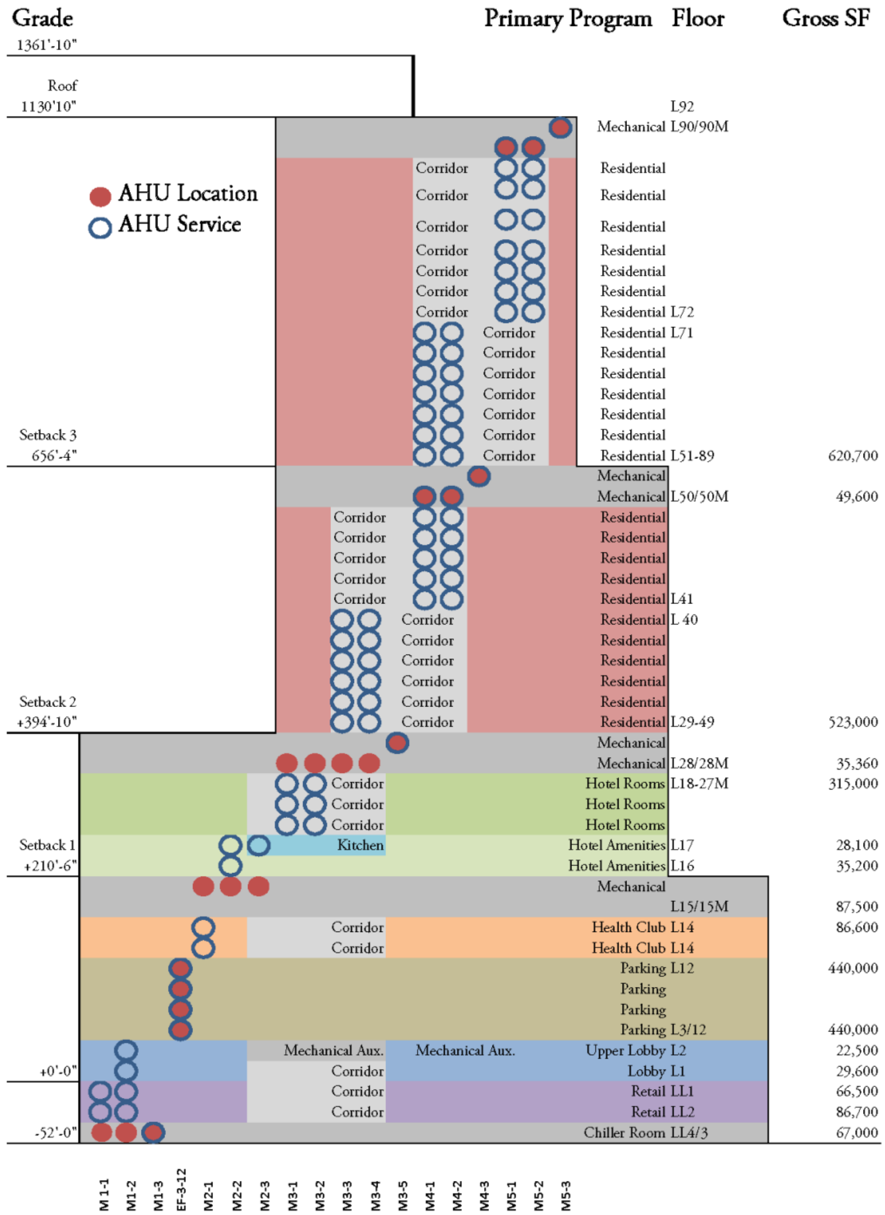

Figure 3: Simplified Air-Side Riser Diagram

On the air side, conditioned air and minimum ventilation air is supplied to each zone from each corresponding air handling unit. Figure 3 provides a simplified air side riser diagram showing the zones served by each air handling unit. Variable speed fans will operate to maintain a positive pressure within the building and will modulate with the load to maintain setpoint temperature and humidity from the mixed conditions of the outside ventilation air and return air. Each air handling unit will utilize a minimum outdoor air damper to maintain minimum ventilation air to each occupied zone. Occupancy schedules for each occupied zone will be set into the automated controls to control the outside air dampers. Air side economizers will be enabled when the outside air temperature is less than 60°F and will operate as required to maintain discharge temperature. Air handling units will also be equipped with morning cool down and warm up. When the zone space temperature rises above 78°F or below 68°F over night, the air handling units will operate to either cool down or warm up the spaces as necessary before occupancy until the desired space temperature is met. If combustion smoke is detected anywhere in any air stream, the supply fan will shut off, and the system alarm will be alerted. Dampers and control valves will then move to normally closed conditions until a command from the building fire system. When the outside air temperature falls below 50°F, electric humidifiers will initiate to raise the humidity of the supply air to the desired setpoint. Static pressure will be measured by two sensors at the penthouse level and two sensors at the lower level. The values will be averaged and their difference taken. Using pressure sensors in the main freight elevator as a reference, the stack pressure will be available to be used by any controller.

The garage exhaust fans will operate when unacceptable CO levels are detected on any given floor. Sensors will be located at least one every 5,000 square feet. Fans will operate for at least 30 minutes until the CO level has decreased to acceptable levels. Unit heaters will operate when temperature sensors indicate that the garage space temperature has dropped below 40°F, but will disable when the exhaust fans are operating.

B.7 SYSTEM INITIAL COST

As mentioned before, much of the equipment sizing, selection, and layout is being performed by the mechanical contractor and is approved by the engineer through submittals. The mechanical contractor for Trump Tower is finalizing the actually design on site. Because of the design assist delivery method, actual system performance and overall system pricing will not be fully known until the project is completed.

The initial costs for the mechanical, plumbing and fire protection systems, however, were approximated and are provided in Table 13. The estimated mechanical system cost includes both the river water intake/outfall system, as well as the control system. The plumbing system includes piping, pumps, fixtures, site water, drainage & sanitary. Overall, the mechanical portion of the project represents approximately 14.6% of the overall budget. This cost may not include all of the labor and unforeseen issues associated with the equipment and installation.

Table 13: Mechanical System Cost Breakdown

System	$	%	$/SF
Mechanical	$41,255,750	7.2%	$1.58
Plumbing	$33,901,600	5.9%	$1.30
Fire Protection	$8,673,577	1.5%	$0.33
Total	**$83,830,927**	**14.6%**	**$3.22**

B.8 LOST SPACE DUE TO MECHANICAL EQUIPMENT

The lost floor space due to the mechanical equipment is summarized in Table 14.

Table 14: Lost Floor Space due to Mechanical System

Program	Floor Number	Mechanical Floor Area (sf)	% of Total Floor Area
Roof Top Mech	Roof	570	0.0%
Mechanical Mezz	M5M	8,480	0.3%
Mechanical	M5	14,290	0.5%
Mech. Mezz	M4M	5,205	0.2%
Mechanical	M4	23,635	0.9%
Mech. Mezz	M3M	13,060	0.5%
Mechanical	M3	33,460	1.3%
Mech. Mezz	M2M	29,260	1.1%
Mechanical	M2	41,790	1.6%
Mechanical	M1	33,530	1.3%
Mechanical	LL2	6,500	0.2%
Mechanical	LL3	1,640	0.1%
Mechanical	LL4	36,740	1.4%
Total		**248,160**	**9.3%**

C SYSTEM PERFORMANCE

C.1 DESIGN VENTILATION REQUIREMENTS

The mechanical systems of Trump International Hotel & Tower in Chicago were evaluated for compliance with the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) Standard 62.1 – 2007 *Ventilation for Acceptable Indoor Air Quality*. This evaluation determines if the mechanical system is able to provide proper ventilation and adequate air quality set forth by the criteria described in ASHARAE Standards 62.1. The Ventilation Rate Procedure as described in Section 6 of ASHRAE Standard 62.1 was used to determine compliance with minimum ventilation requirements and is based upon floor areas, space utilization, occupancy and type of ventilation system. The layout and design of the ventilation system was analyzed for compliance with the criteria of Section 5 of ASHRAE Standard 62.1 to ensure clean outdoor air is supplied to building occupants, that contaminated air is exhausted, and the system is designed to maintain cleanliness of handled air.

Nearly all of the spaces within Trump Tower met the minimum ventilation requirements set forth by the ventilation rate procedure. There were a few spaces, however, which did not meet the minimum ventilation requirements of ASHRAE Standard 62.1 including a few administrative offices on the 2nd floor, the health club locker rooms and a studio on the 14th floor, as well as the employee cafeteria and a banquet hall on the 15th and 16th floor respectively. The parking garage floor ventilation systems comprise of four exhaust fans (two in the case of Level 3) removing 35,000 total CFM per floor of parking garage. With 44,410 GSF of garage space on each floor, ventilation exhausts greater than 0.80 CFM/SF of air. This exceeds the minimum exhaust rate of 0.75CMF/SF. Exhaust fans are located on the Plan West side of the building and air intake louvers to provide 35,000 CFM of makeup outdoor air are provided on the Plan East side of the building. This will ensure steady outdoor air flow across the parking garage floor. For a complete summary of compliance with the ventilation rate procedure and detailed spreadsheet calculations for each space please refer Technical Assignment 1: ASHRAE Standard 62.1 & 90.1.

C.2 HEATING & COOLING LOAD ESTIMATE

Block loads and energy estimates were performed on Trump International hotel & Tower in Chicago using the whole building energy simulation program *Trace 700* developed by Trane. This evaluation estimates the design load, annual energy consumption and operating costs of the project. Block loads are estimated by occupancy type for simplification to achieve a reasonably accurate estimate of the energy consumption of the building. Information used in the energy model is determined from actual design assumptions, materials, and equipment information provided in the drawings and specifications.

Table 15 summarizes the total cooling tonnage, the supply air CFM as well as the ventilation air CFM for both the calculated load and the design load. The calculated load was slightly less than the design load in each category. The assumptions in the energy model leave out a large portion of the mechanical system including the energy from the pool dehumidification unit, the residential internal heating loads that may come from high-end entertainment units and larger than simulated latent loads from the health club. In addition, perhaps the anticipated occupancy densities are higher than those provided for minimum ventilation rates per ASHRAE Standard 62.1. In addition, the curtain wall system with the dry gasket seal may perform different than the overly simplified simulation of the energy model. The heating system for Trump Tower is entirely electric and will be discussed further in system energy use. For a more detailed analysis of the system loads please refer to Technical Report 2: Building & Plant Energy Analysis.

Table 15: Calculated and Designed Total Loads & Supply CFM

Calculated	Tons Cooling	Supply Air CFM	Ventilation CFM
Total	4,068.7	567,055	171,874
SF/Ton	639	4.6	12.1

Designed	Tons Cooling	Supply Air CFM	Ventilation CFM
Total	4,800	633,700	329,500
SF/Ton	541	4.1	7.9

C.2 SYSTEM ENERGY USE

Since the publication of Technical Report 2, the engineer has provided the results of their own energy analysis. Results from an energy simulation performed for Technical Report 2 determined Trump Tower would utilize 44,719,916 kWh/year. The engineer determined the electric utilization would be 20,273,000 kWh/year. The discrepancy is likely due to varied design assumptions with the electric baseboard heating and lighting power densities. Their results reflect more detailed design intentions and assumptions and will be reported here. For a detailed description of the performed energy simulation, please refer to Technical Report 2: Building & Plant Energy Analysis. Table 16 summarizes the results from the engineer of the annual building energy consumption.

Table 16: Annual Building Design Energy Consumption

Zone	Electric (kWh)	Gas (therm)
Condo	8,856,000	194,000
Hotel	4,841,000	143,000
Hotel Amenities	1,230,000	4,000
Health Club	721,000	21,000
Spa Suites	524,000	21,000
Restaurant & Kitchen	156,000	5,400
Banquet Kitchen	126,000	4,900
Room Service Kitchen	8,000	2,900
Parking	816,000	-
Lobby	370,000	-
Retail	568,000	3,100
Base Building	2,057,000	1,400
Total:	**20,273,000**	**400,700**

D LEED-NC VERSION 2.2

D.1 ENERGY AND ATMOSPHERE

Energy and Atmosphere section of LEED provides requirements and guidelines to reduce the energy consumption of the building mechanical design. In this section there are three manditory prerequisits and up to 17 available points over 6 credits. The most notible credit with 10 points available, Optimize Energy Performance is questionable for a building with a nearly 100% glass façade such as Trump Tower. This credit and its prerequisit, Minimum Energy Performance are questionable and truly dependon the design assumptions made interpreting ASHRAE standards and on the energy simulation results. Credit 4, Enhanced Refrigerant Management and its prerequisit, Fundamental Refrigerant Management are easily achieved as R-134A is specified for the chilled water plant of Trump Tower and does not contain any chlorofluorocarbons (CFCs). Credit 3, Credit 5 and Credit 6 are achievable as per the design but there is not necessarily a plan in place to performand document the enhanced comissioning, acountability of the system or to purchase green power. If a plan were put in place early on in the design process these credits would have been easily achievable. Table 17 summarizes potential obtainable credits in the Energy & Atmosphere category.

Table 17: Attainable Energy & Atmosphere LEED-NC 2.2 Credits

Credit	Description	Points Available	Attainable as per Design
EA Prereq 1	Fundamental Commissioning	Required	Yes
EA Prereq 2	Minimum Energy Performance	Required	Yes
EA Prereq 3	Fundamental Refrigerant Management	Required	Yes
EA Credit 1	Optimize Energy Performance	1 to 10	Maybe
EA Credit 2	On-Site Renewable Energy	1 to 3	No
EA Credit 3	Enhanced Commissioning	1	Yes, If Planned
EA Credit 4	Enhanced Refrigerant Management	1	Yes
EA Credit 5	Measurement & Verification	1	Yes, If Planned
EA Credit 6	Green Power	1	Yes, If Planned

D.2 INDOOR ENVIRONMENTAL QUALITY

Indoor Environmental Quality section of LEED is an attempt to ensure a healthy indoor environment for building occupants. Many of the credits achieved in this section are achievable by determination of the architect and contractor, rather than the mechanical engineer. The mechanical engineer can advise on how to achieve these credits but it is up to the contractor to provide a construction indoor air quality management plan, and it is up to the architect to specify low chemical emitting paints, carpet systems and materials. This section has a total of 15 points available across 8 credits with two prerequisits. There are 7 credits including the two prerequisits that concern the mechanical engineer. The first manditoryprerequisit requires compliance with ASHRAE Standard 6.1 For prerequisit 2, Environmental Tobacco Smoke Control, the city of Chicago has a smoking ban in all public spaces. Credit 1 requires occpancy sensors, which are not specified in this design. Occupancy is input into the control system by manual schedules but is not verified. Fan coil units and operable windows are provided in all residential portions of the building which may or may not be enough to achieve Credit 6.2. The current design can apply for this credit, but the ultimate awarding of the credit would have to be confirmed and granted by the USGBC. Credit 7.1 is easily achieved but a verification plan would need to be implemented in order to achieve Credit 7.2 Table 18 summarizes applicable obtainable credits in the Indoor Environmental Quality category.

Table 18: Attainable Indoor Environmental Quality LEED-NC 2.2 Credits

Credit	Description	Points Available	Attainable as per Design
IEQ Prereq 1	Minimum IAQ Performance	Required	Yes
IEQ Prereq 2	Environmental Tobacco Smoke Control	Required	Yes
IEQ Credit 1	Outdoor Air Delivery Monitoring	1	No
IEQ Credit 2	Increased Ventilation	1	No
IEQ Credit 6.2	Controllability of Systems: Thermal Comfort	1	Maybe
IEQ Credit 7.1	Thermal Comfort: Design	1	Yes
IEQ Credit 7.2	Thermal Comfort: Verification	1	Yes, If Planned

E SYSTEM EVALUATION

The ultimate energy efficiency objective of the HVAC system is to never reject heat from a space when there is heat gain within the space and conversely never impose heat upon a space when there is heat loss from the space. Peak occupancy loads, however, rarely coincide with peak thermal gains and losses. Many building occupancies have diurnal cycles. With the high percentage of glass curtain wall façade transmitting considerable solar radiation, in nearly any season the HVAC system will be required to cool some spaces in Trump Tower. During the cooler evening there is heat loss from the space. To maintain set point temperatures it is likely that the HVAC system would be required to heat the space during the evening. This cycle increases peak power demand and requires an oversized HVAC system.

The most unique design feature of the system selected by the mechanical engineer is the utilization of the Chicago River as condenser water. The condenser water system saves significant energy in comparison to the cooling tower alternative. It also eliminates the need for the pumps, pump energy, piping, piping shaft space, and added volume of condenser and make up water required to transport the condenser water up the 1,400 vertical feet from the chiller room to the roof to cooling towers. In addition, it allows for a more refined architectural statement eliminating the need for unsightly cooling towers crowning the building.

Although the nearly solid reflective glass facade gives Trump Tower a light weight feel, the unadorned continuity of the glazing gives the tower a strong confidence. Any impedence upon the façade would take away from that confidence. Unit ventilators are comon terminal units in many hotels; They are inexpensive and low maintainance. They require direct ventilation in each zone they serve, however and would specle the façade with hundreds of exterior louvers. Using fan coil units rather than unit ventilators is an ideal alternative to preserve the solid façade by providing internal ventilation.

Integrative design solutions could be considered to reduce ambient load profiles rather than significantly overhauling the mechanical system design. For instance, the sheer mass of the concrete structure of Trump Tower could be advantageously exploited by implementing Phase Change Materials (PCMs) into the concrete itself. PCMs take advantage of latent heat of fusion to store large amounts of heat energy without a significant rise in temperature. As the material is exposed to heat gain, the solid material melts and absorbs energy. The liquid material will then release heat as it freezes back to a solid. This form of latent energy storage acts as a reservoir of energy, able to react to the changing intensities of solar energy throughout the day.

The façade has very clean lines and is empowering to view from a great distance, but looking at the façade closely from the inside may be dangerous. Operable windows are integrated into the curtain wall design in the hotel and residential portions of the building to allow for natural ventilation, but they are at the floor and open downward as shown in Figure 4. There is no screen to prevent anything from falling out the window. If a young child were to find their way to the window and fascinated with the view they may be able to open the window and fall out. It is also quite easy to accidently drop something out the window creating a dangeours situation not only for the building occupants, but for passing observers down below. The windows may open down to keep out the rain, and they may be at the floor to draw in fresh air, but no design consideration is more important than occupant safety.

Figure 4: Open Operable Window Facing Down at Floor Level in Trump Tower

Fan coil terminal units in the hotel and residential portions of the building provide inexpensive thermal comfort to the occupants but is also not the most energy efficient or advanced design solution. Improvements could easily be made to the control system rather than the actual system. Sophisticated control systems for the hotel and residential portion of the building could provide energy efficiency as well as provide the luxurious experience inherent to the Trump brand. These control systems could simply stem from include key card occupancy sensors. When a guest room is unoccupied, curtains would remain closed to minimize solar heat gain and exfiltration heat loss. Lights and air conditioning would be off. When a guest enters the room, the curtains would open and the lights would turn on. Advanced control systems could allow for automated air conditioning control with user over-ride for hotel guests rather than thermostat based fan and temperature control. This opens to a wide range of possible integrative design solutions.

Numerous integrative design solutions could be considered to reduce ambient load profiles rather than significantly overhauling the mechanical system design. As another example the sheer mass of the concrete structure of Trump Tower could be advantageously exploited by implementing Phase Change Materials (PCMs) into the concrete itself. PCMs take advantage of latent heat of fusion to store large amounts of heat energy without a significant rise in temperature. As the material is exposed to heat gain, the solid material melts and absorbs energy. The liquid material will then release heat as it freezes back to a solid. This form of latent energy storage acts as a reservoir of energy, able to react to the changing intensities of solar energy throughout the day.

Trump Tower utilizes several creative design solutions but does not maximize potential of energy efficiency. The condenser water system takes advantage of utilizing the Chicago River to dissipate heat, but the building heating system is the archaic electric resistance. Taking advantage of several integrative design solutions and maximizing the potential of the current systems may be able to optimize energy utilization and provide a reduction in mechanical system footprint without overhauling the mechanical system design.

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