McCarran International Airport
Terminal 3
Las Vegas, NV

Technical Assignment 2

Building and Plant Energy Analysis Report

October 29, 2007

Prepared By:
Jason A. Witterman
Mechanical Option

Faculty Advisor:
Dr. William Bahnfleth, Ph.D., P.E.

Table of Contents

Executive Summary

This report covers various aspects of energy analysis for Terminal 3 at McCarran International Airport in Las Vegas, NV. These areas include compliance with ASHRAE Standard 90.1-2004, certification under LEED-NC V2.2, initial system cost, system space requirements, load estimates, and annual cost estimates.

Terminal 3 is evaluated based on all relevant sections of ASHRAE Standard 90.1-2004 as listed in this report. While most of the analysis indicates that Terminal 3 does indeed comply with the standard, there are some aspects that may not comply. This is largely due to the fact that the project is actually governed by International Energy Conservation Code (IECC) 2003, and not ASHRAE Standard 90.1-2004.

While Terminal 3 did not seek LEED certification, a basic analysis was performed in this report. The findings of this analysis indicate that under the current design, Terminal 3 would not earn enough credits to be LEED certified. However, further analysis shows that Terminal 3 could likely reach the lowest certification level with some minor design changes.

The total estimated first cost of the HVAC system for Terminal 3 and related projects is approximately $87.6 Million. This mechanical system is also estimated to use 7.44% of the overall building area, or 3.8% of the area on the normally occupied levels.

Finally, Trane TRACE is used to perform load estimations, as well as annual energy consumption estimates. This data is provided by the mechanical design engineer, and represents the estimates used to size and design the HVAC systems for Terminal 3. A new analysis could not be performed due to lack of feasibility and other limitations. This load model indicates that the actual system design closely matches the estimates output by the software. Annual energy consumption rates and annual cost are also determined from this analysis. However, since this model was never intended for such analysis, the results are certainly overestimated, and therefore considered inconclusive. Future work on the overall project will lead to more accurate results than those explained in this report.

Summary of Mechanical Systems

Terminal 3 is served by (88) air handling units, with an additional (3) units serving the central plant. A summary of these airside systems can be found in a separate report, Technical Assignment 1: ASHRAE Standard 62.1-2007 Ventilation Compliance Evaluation.

The waterside components of Terminal 3 are mentioned briefly in this report, and therefore are summarized here for clarification. A more detailed explanation of these systems will be provided in Technical Assignment 3: Evaluation of Existing Mechanical Systems. All waterside requirements of Terminal 3 are provided for by a new central utility plant. This plant is sized to meet the load requirements of Terminal 3, Satellite D, and the Automated Transportation System (ATS) tunnel that connects these two facilities. A breakdown of the load estimates for these facilities is included in this report under the section titled Estimation of Design Loads. The chilled water for these facilities is to be provided by (5) 2,200 ton centrifugal chillers. An additional chiller of equal capacity is provided as standby. The cooling towers for this system will be field erected concrete cells with (1) cell for each chiller. The heating hot water requirement for the buildings is provided by (6) boilers providing an output of 17,570 MBH each. An additional boiler of equal capacity is also provided as standby.

Evaluation of LEED-NC Version 2.2 Certification

The Leadership in Energy and Environmental Design (LEED) Green Building Rating System provides criteria for the evaluation of sustainable building projects. LEED is developed under the United States Green Building Council (USGBC) and is considered to be the standard for the evaluation of green buildings. At the time of this report, LEED-NC Version 2.2 is the current rating system used for the evaluation of new construction. Various degrees of certification are then awarded based on the number of credits achieved during the evaluation process.

While Terminal 3 did not seek LEED certification, this report provides a basic summary of the potential for certification. It is important to note that the analysis contained in this report is purely speculative. In reality, a building is not LEED certified until it has been documented that all necessary requirements have been met. Table 1 – Summary of LEED-NC Checklist provides the results of the analysis performed for this report. A full copy of the checklist used for evaluation can be found in Appendix A.

Table 1 – Summary of LEED-NC Checklist

Credit Category	Current Design	Feasible Design
Sustainable Sites	1	3
Water Efficiency	1	4
Energy and Atmosphere	1	3
Materials and Resources	0	3
Indoor Environmental Quality	2	10
Innovation and Design Process	1	2
Total	**6**	**25**

Table 1 shows that Terminal 3 is likely capable of achieving 6 credits with the current design. However, this table also shows that slight design modifications could allow the project to obtain an additional 25 credits. Together, these 31 credits would allow Terminal 3 to reach a certification level of Certified. While this is the lowest level of certification possible, the goal of this analysis was to investigate the potential for LEED certification with little or no additional first cost.

There are many potential reasons why Terminal 3 did not seek LEED certification. The first of these is the concept that the use of the facility simply does not allow for easy implementation of sustainable practices. For example, public transportation is not widely used in Las Vegas and therefore it was assumed that all of the credits in that area could not be reasonably obtained. Likewise, portions of the facility are subject to drastic changes in load profiles whereas other areas are operated on a nearly continuous basis. As a result, it may be difficult to obtain the points under EA credit 1. Another reason why LEED was not incorporated into this project relates to the concept of cost. If the conditions are favorable, minimum certification can likely be obtained for nearly no increase in first cost. However, the increase in initial cost for Terminal 3 can be expected to be slightly higher than the average. This is a result of the feasibility mentioned previously, as well as the size of the building.

Analysis of Compliance with ASHRAE Standard 90.1-2004

ASHRAE Standard 90.1-2004 provides minimum requirements for the energy-efficient design of buildings. According to Section 4.2.1.1 of the standard, new buildings shall comply with Sections 5, 6, 7, 8, 9, and 10 of the standard. Alternatively, the building can be evaluated by the Energy Cost Budget Method outlined in Section 11. This report will determine compliance with Sections 5, 6, 7, 8, 9, and 10; as opposed to Section 11.

Building Envelope Compliance

ASHRAE Standard 90.1-2004 Section 5 specifies the compliance requirements for the building envelope. The first step in the evaluation process is to classify the building under a space-conditioning category. According to Section 5.1.2.1 and the definitions in Section 3.2, Terminal 3 is classified as nonresidential conditioned space. The next step in the process is to determine the climate zone for the project location in accordance with Section 5.1.4. McCarran International Airport – Terminal 3 is located in Las Vegas, NV; which is part of Clark County. According to ASHRAE Standard 92.1-2004 Table B-1, Clark County is classified as climate zone 3B.

There are (2) methods for verifying building envelope compliance. These compliance paths are outlined in Section 5.2. This report will evaluate building envelope compliance in accordance with the Prescriptive Building Envelope Option. In order to utilize this method, the vertical fenestration area of the building cannot exceed 50% of the gross wall area, and the skylight fenestration area cannot exceed 5% of the gross roof area. Verification of these requirements is demonstrated as follows:

$$Vertical\ Fenestration\ Area = \frac{66{,}560\ SF}{478{,}074\ SF} = 13.92\% < 50\% \Rightarrow OK$$

$$Skylight\ Fenestration\ Area = \frac{15{,}538\ SF}{589{,}524\ SF} = 2.64\% < 5\% \Rightarrow OK$$

Looking at the project specifications, it appears that all mandatory provisions listed in Section 5.4 have been met. That being said, Section 5.5 can be used to evaluate whether or not Terminal 3 complies with ASHRAE Standard 90.1-2004.

The notes contained in Section 5.5 are used in conjunction with Appendix A and Table 5.5-3 to determine the minimum requirements for the building envelope. These minimum requirements, as well as the actual design values from Terminal 3 are summarized in Table 2 and Table 3. Based on the analysis performed, Terminal 3 appears to comply with the requirements outlined in ASHRAE Standard 90.1-2004 Section 5.

Table 2 – Building Envelope Compliance Summary for Opaque Elements

Opaque Elements	Required by ASHRAE 90.1-2004	As Designed	Compliance
Roof, Insulation Entirely above Deck			
Insulation Minimum R-Value	R-15 Continuous Insulation	2.5" R-30 Continuous Insulation	Complies
Walls, Above Grade, Metal Building			
Insulation Minimum R-Value	R-13	R-19 Batt Insulation	Complies
Walls, Below Grade			
Insulation Minimum R-Value	NR	N/A	Complies
Floors, Mass			
Insulation Minimum R-Value	R-6.3 Continuous Insulation	R-8.6 Continuous Insulation	Complies
Doors, Swinging			
Assembly Maximum U-Value	U-0.7	U-0.25	Complies

Table 3 – Building Envelope Compliance Summary for Fenestration

Fenestration Elements	Required by ASHRAE 90.1-2004	As Designed	Compliance
Vertical Glazing, 10.1 - 20% of Wall			
Assembly Maximum U-Value	U_{fixed}-0.57	U_{fixed}-0.29	Complies
Assembly Maximum SHGC	$SHGC_{all}$-0.25	$SHGC_{all}$-0.24	

Heating, Ventilating, and Air Conditioning Systems Compliance

ASHRAE Standard 90.1-2004 Section 6 includes the compliance requirements of HVAC systems and equipment. There are two compliance paths that are outlined in Section 6.2 The first of these compliance paths involves meeting all of the requirements of Section 6.3, Simplified Approach Option for HVAC Systems. However, this path can not be chosen since the project does not meet the conditions necessary to use this method. As a result, compliance is determined in accordance with Section 6.4, Mandatory Provisions; and Section 6.5, Prescriptive Path.

The first step in this analysis is determination of minimum equipment efficiencies under Section 6.4.1. These minimum efficiencies are found in Tables 6.8.1A through 6.8.1G of the standard. After determining these minimum efficiencies, it is necessary to verify that the actual equipment efficiencies are higher than these minimums. The results of this process are listed in Table 4 – HVAC Equipment Compliance Summary.

Section 6.4.2 of the standard requires that load calculations be performed using acceptable methods. It is assumed that this requirement has been satisfied. Similarly, Section 6.4.3 specifies requirements of the system controls. Review of the construction documents indicates that these requirements are likely met. The final requirements of Section 6.4 are minimum duct and pipe insulations. This topic is covered in Section 6.4.4 of the Standard, with the minimum values listed in Table 6.8.2 and Table 6.8.3 of the standard. In accordance with Table 6.8.2B of the standard, there is no minimum duct insulation thickness because the ductwork is routed in indirectly conditioned spaces. Despite this, Section 15083 of the Terminal 3 specifications still requires duct insulation for some ductwork. The minimum pipe insulation thickness required and installed is summarized in Table 5 – Pipe Insulation Thickness Compliance Summary. Based on the analysis performed, Terminal 3 is considered compliant with

ASHRAE Standard 6.4. The only possible exception to this is domestic water piping 1.5" to 4" in size, as noted in Table 5.

Table 4 – HVAC Equipment Compliance Summary

System Component	Minimum Efficiency Required		Actual Equipment Efficiency		Compliance
Boilers	E_c		E_c		Complies
Gas Fired Boiler	80%		85%		
Size Category: >2,500,000 Btu/h					
Subcategory: Hot Water					
Chillers	COP	NPLV	COP	NPLV	Complies
2,200 Ton Centrifugal Chiller	5.9	6.16	6.1	7.29	
Entering Condenser Water: 85°F					
Leaving Chilled Water: 42°F					
Condenser Flow: 3 gpm/ton					
Cooling Towers	gpm/hp		gpm/hp		Complies
Propeller Fan Cooling Tower	≥ 38.2 gpm/hp		88 gpm/hp		
Entering Condenser Water: 95°F					
Leaving Condenser Water: 85°F					

Table 5 – Pipe Insulation Thickness Compliance Summary

	Nominal Pipe Size [in]					Compliance
	< 1	1 to < 1.5	1.5 to < 4	4 to < 8	≥ 8	
Heating Hot Water Piping (200 °F Supply)						
Required [in]	1.0	1.0	1.0	1.5	1.5	Complies
Installed [in]	1.5	1.5	1.5 to 2	2.0	2.0	
Chilled Water Piping (42 °F Supply)						
Required [in]	0.5	0.5	1.0	1.0	1.0	Complies
Installed [in]	1.0	1.0	1 to 1.5	1.5	1.5	
Domestic Hot Water (> 105 °F Supply)						
Required [in]	0.5	0.5	1.0	1.0	1.0	May Not Comply
Installed [in]	0.8	0.8	0.75 to 1	1.0	1.0	

Note: Domestic hot water piping 1.5" to 4" may or may not comply with ASHRAE Standard 90.1-2004. Section 15083 of the Terminal 3 specifications permit a minimum 0.75" of insulation for pipe sizes less than 2.5". This does not comply with the standard.

Compliance with Section 6.5 is not analyzed in depth within this report. This section of the standard specifies equipment requirements in addition to those listed in Section 6.4. Some examples of such requirements are included here for the purpose of an overall analysis.

The first example of Section 6.5 requirements is the need for economizers. In accordance with Table 6.5.1 of the standard, an economizer is required for all systems with a cooling capacity greater than 65,000 Btu/h. These economizers are indeed included as necessary in the form of an air economizer.

Another example of requirements under Section 6.5 is the use of energy recovery. Section 6.5.6.1 provides one specific example of such a requirement. This section states that exhaust air energy recovery shall be incorporated for systems with a minimum outdoor air supply greater than 70% of the design supply air quantity. The air handling unit schedules for Terminal 3 show that all systems serving inbound / outbound baggage handling areas are indeed designed to provide an outdoor air fraction greater than 70%. However, these systems are exempt from the requirements due to the fact that they are used to exhaust carbon monoxide from the space.

Once again, since Terminal 3 is not required to conform to ASHRAE Standard 90.1-2004, it is quite possible that some of the requirements of section 6 of the standard have not been met. In order to determine for certain whether or not compliance with this section is achieved, a significant amount of in depth analysis would be required. Such an analysis is not feasible for the purposes of this report. As a result, no final statement of compliance can be made with regards to ASHRAE Standard 90.1-2004 Section 6.

Service Water Heating Compliance

ASHRAE Standard 90.1-2004 Section 7 specifies the compliance requirements for service water heating systems and equipment. In the case of Terminal 3, compliance is determined in accordance with Section 7.4, Mandatory Provisions. Section 7.5, Prescriptive Path, does not apply to this project as the domestic water heating and space heating systems are separate.

Section 7.4.2, Equipment Efficiency, is the basis for determining compliance of water heating equipment. This section requires that all water heating equipment meet the criteria listed in Table 7.8 of the standard. The construction documents for Terminal 3 indicate that domestic hot water will be provided by electric water heaters located within mechanical rooms. Furthermore, plumbing schedules indicate that all water heaters have an input of less than or equal to 12 kW. Table 7.8 provides the following equation for determining the minimum required performance of the domestic water heaters.

$$Performance\ Required = 0.93 - (0.00132 \times Volume)$$

Substituting the various water heater capacities into this equation provides the minimum requirements for the various water heaters. Unfortunately, manufacturer's data could not be found to determine the actual performance characteristics of the water heaters. However, the manufactures catalog (A.O. Smith) does indicate that all water heaters of this model series (DSE models) meet or exceed the requirements of ASHRAE Standard 90.1. Therefore, it is assumed that compliance with this section has been achieved.

Further inspection of the plumbing construction documents indicates that the remaining portions of Section 7.4 appear to be considered, and all requirements seem to be met. As a result, the service water heating systems are determined to be compliant with ASHRAE Standard 90.1-2004 Section 7.

Power Distribution Compliance

ASHRAE Standard 90.1-2004 Section 8 indicates the compliance requirements of power distribution systems within a building. Compliance with this section is determined in accordance with Section 8.4 which contains mandatory provisions for the distribution system. ASHRAE Standard 90.1-2004 lists maximum voltage drops as the only criteria for determining compliance with this section. Section 8.4.1 of the standard states the criteria as follows:

- Electrical feeders shall be sized for a maximum voltage drop of 2% at design load.
- Branch circuit conductors shall be sized for a maximum voltage drop of 3% at design load.

The power distribution system for Terminal 3 was designed to satisfy both of these requirements. While detailed calculations are not included in this report, it is assumed that the final design does indeed meet the voltage drop requirements it was designed for. Therefore, Terminal 3 is considered to comply with the provisions of ASHRAE Standard 90.1-2004 Section 8.

Lighting System Compliance

ASHRAE Standard 90.1-2004 Section 9 specifies the compliance requirements for the lighting systems serving the building. Compliance with this section is mostly determined in accordance with Section 9.5, Building Area Method; or Section 9.6, Space-by-Space Method. This report will utilize the simplified building area method to determine compliance.

Buildings are also required to comply with Section 9.4, Mandatory Provisions. Most of this section is about requirements for controls of the lighting systems, as well as requirements for exterior lighting. After reviewing the design documents, it appears that the requirements of Section 9.4 have been met. Additionally, Section 9.4.5 indicates that most of the project is exempt from the exterior lighting requirements. This is permitted as a majority of the exterior lighting is required for the safety of operations on the airport ramp or departures roadway. Overall, it is assumed that Terminal 3 is compliant with all of the requirements listed in Section 9.4.

Now the building area method is used to finish the compliance analysis. The first step in utilizing the building area method is to determine the appropriate building type, and corresponding allowable lighting power density. This data is obtained from Table 9.5.1 of the standard. Terminal 3 is considered to be a transportation facility, and therefore an allowable lighting power density of 1.0 W/ft^2 will be used throughout the building. This allowable lighting power density is then multiplied by the gross lighted floor area of the building. The result is the interior lighting power allowance, which can be found in Table 6 – Lighting System Compliance Summary.

The final step in determining compliance under this method is to determine the actual lighting power levels within the building. This calculation was performed by summing the actual wattage of the various luminaires throughout the building. Refer to Table B1 in Appendix B for actual lighting power levels per luminaire type. The results of this calculation are also shown in Table 6.

Table 6 – Lighting System Compliance Summary

Gross Lighted Floor Area [SF]	1,873,645
Allowable Lighting Power Density [W/SF]	1.0
Interior Lighting Power Allowance [W]	**1,873,645**
Installed Interior Lighting Power [W]	**1,364,260**

Looking at Table 6, it is clear that the installed interior lighting power value is lower than the interior lighting power allowance value. In accordance with Section 9.5.1, the lighting system of Terminal 3 is found to be compliant with ASHRAE Standard 90.1 Section 9.

Other Equipment (Motors) Compliance

ASHRAE Standard 90.1-2004 Section 10 states the compliance requirements for equipment not listed in Section 6. This equipment consists of the electric motors used throughout the building. Compliance of these motors is determined in accordance with Section 10.4, Mandatory Provisions. Specifically, Section 10.4.1 states electric motors shall comply with the requirements specified in Table 10.8 of the standard. Typical verification of compliance with this section would require that the actual motor efficiencies are higher than the minimum efficiencies listed in Table 10.8 of the standard. For the purposes of this report, motors will not be analyzed on an individual basis. This detailed analysis was deemed unfeasible due to a lack of necessary manufacturer's data. Instead, the efficiencies of the motors are analyzed on an overall basis.

The first part of the overall analysis takes a look at those motors equipped with variable frequency drives (VFD's). It is important to realize that with few exceptions, most all air handling units are equipped with VFD's. Similarly, almost all of the pumps in the central plant are equipped with VFD's. The (2) pumps that are an exception to this are the chemical feeds for the cooling towers. The general mechanical notes state that premium efficiency motors shall be used where VFD's are specified. As a result, it is reasonable to assume that these premium efficiency motors comply with the requirements outlined in ASHRAE Standard 90.1 Section 10.

The second part of the overall analysis required an evaluation of the motors that are not equipped with VFD's. These motors are mostly associated with the exhaust fans for the terminal. The project specifications were consulted for this portion of the analysis. Section 15051 Part 1.7A states that all motors shall conform to local energy code. However, it is important to remember that Terminal 3 is not required to comply with ASHRAE Standard 90.1-2004. Instead, the project is governed by International Energy Conservation Code (IECC) 2003. While IECC 2003 does make mention to motors in Section 503 (similar to ASHRAE Standard 90.1-2004 Section 6), it does not appear to include requirements similar to those in ASHRAE Standard 90.1-2004 Section 10.

This being said, it is not possible to determine whether or not all motors are compliant with ASHRAE Standard 90.1-2004 Section 10. While the motors equipped with VFD's are likely compliant, other motors used elsewhere may or may not comply.

Lost Rentable Space Due to Mechanical System

This section provides an explanation of the lost rentable space as a result of the building mechanical system. Terminal 3 has an official total building area of 1,873,645 SF; as found on the architectural construction documents. This value excludes Level 3 which serves only as mechanical penthouse space. The individual floor areas of all levels are shown in Table 7 – Area Breakdown below.

Since Level B and Level 3 are designated as spaces for the building systems, they are not considered to be rentable spaces. As a result, the analysis is performed for two scenarios. The first calculation takes into account all levels and spaces within Terminal 3. The second calculation takes into account only those spaces considered to be rentable. This includes only Level 0, Level 1, and Level 2. The results of both of these calculations are also represented in Table 7.

Table 7 – Area Breakdown

Space	Total Gross Area [GSF]	Area Occupied by Mechanical Systems [GSF]	Percent of Floor Area [%]
Level B	88,580	11,859	13.39%
Level 0	600,838	0	0.00%
Level 1	578,560	51,139	8.84%
Level 2	605,667	16,624	2.74%
Level 3	64,629	64,629	100.00%
Total (All Levels)	**1,938,274**	**144,251**	**7.44%**
Total (Levels 0, 1, 2)	**1,785,065**	**67,763**	**3.80%**

Notes:

1. Total (All Levels) includes all spaces within the Terminal. This includes the Level 3 Penthouse spaces, which are not considered to be a part of the official 1,873,645 SF building area.

2. Total (Levels 0, 1, 2) includes only the 'rentable' spaces within the Terminal. This value excludes Level B, which contains only mechanical and electrical support spaces; as well as Level 3, which contains only mechanical penthouse space.

Mechanical System First Cost

The cost data provided in this section includes Terminal 3, as well as the projects associated with it. Since the project has not yet been constructed or bid, the data in this report reflects a 100% Design Cost Estimate performed by Faithful + Gould. This cost estimate was performed in August 2007 for Terminal 3 and the ATS tunnel, and September 2007 for the central plant and early package. These estimates fall under separate contracts, and reflect the most up to date data for the project. The cost data for Terminal 3 and the associated projects is provided in Table 8 below. It should be noted that these cost estimates are for HVAC items only. Other items that may fall under the mechanical discipline, such as fire protection and plumbing, have been omitted from these values.

Table 8 – Mechanical Cost Data

Project Area	Area [SF]	HVAC System Initial Cost	HVAC System Initial Cost per SF
Terminal 3	1,873,645	$61,994,928	$33.09
ATS Tunnel and Stations	222,335	$6,983,745	$31.41
Central Plant	66,950	$18,658,073	$278.69
Total	**2,162,930**	**$87,636,746**	**$40.52**

The cost data for the terminal includes all HVAC equipment (i.e. air handling units, fans, terminal boxes, and fan coil units). All waterside and airside distribution systems are also included in this estimate, as well as controls. Finally, this value also includes all general mechanical costs such as testing and balancing, commissioning, and other start up work. The estimate for the ATS tunnel and stations includes the items similar to those listed for the terminal. This estimate also includes the air handling units located on the south end of the tunnel at Satellite D, as well as all associated distribution systems. Finally, the cost estimate for the central plant takes into account all equipment located in the plant itself. This includes the chillers, boilers, cooling towers, pumps, and fans. This cost also reflects the air handling equipment and distribution systems serving the central plant.

Estimation of Design Loads

This section of the report contains the analysis performed by the mechanical consultant for Terminal 3. Due to software limitations and lack of feasibility, a new load estimate could not be performed for comparison in this report. It is anticipated that a new load simulation model will be performed in the future for further use in the overall thesis project.

Load estimates for Terminal 3 were determined through the use of TRACE 700 by Trane. This software takes into account the actual design occupancy values, lighting and equipment electrical loads, and outdoor air ventilation rates. Furthermore, TRACE uses design indoor and outdoor conditions to appropriately model the building based on the climate. Indoor design conditions are assumed to be 75°F DB / 50% or less RH for summer and 72 F DB / 50% or less RH for winter. The design outdoor air temperatures are represented in Table 9, with ASHRAE recommended design conditions provided for comparison.

Table 9 – Design Outdoor Air Temperatures

Annual Cooling Design Conditions			
ASHRAE 2005, 0.4%		TRACE Weather Data	
Cooling DB	Evaporation WB	Cooling DB	Evaporation WB
108.4 °F	71.4 °F	108 °F	66 °F
Annual Heating Design Conditions			
ASHRAE 2005, 99.6%		TRACE Weather Data	
Heating DB		Heating DB	
28.9 °F		27 °F	

Table 10 compares the results of the load simulation to the actual building design loads. Please note that this table does not include data for the following systems: air handling units serving substations, evaporative coolers serving the central plant boiler rooms, and fan coil units used throughout the project. Overall, the design loads seem to be reasonably close to the estimated loads. However, there are several systems that appear to be overdesigned. On the other hand, it is important to note that Terminal 3 is equipped with demand controlled ventilation, so the differences in design outdoor air flow rates are not an energy concern. Similarly, the air handling units are also equipped with variable frequency drives to help reduce energy usage when not operating at peak load conditions. The final reason for some differences is a result of simple modeling differences. Small changes have been likely made in the design documents without being modified in the load simulation. These changes will likely be incorporated into an updated load simulation for future analysis.

The calculated block cooling load for Terminal 3 and related projects is 9,600 tons. An additional 2,400 ton block load is calculated for Satellite D. This results in a total block load of 12,000 tons. However, taking into account a 90% load diversity factor results in a cooling load requirement of 10,800 tons. The estimated heating load for Terminal 3 and related projects is 76,166,959 Btu/h. An additional

33,280,000 Btu/h load is calculated for Satellite D. This results in a total heating load of 109,446,959 Btu/h. Again, assumption of a 90% load diversity factor results in a total heating load of 98,502,263 Btu/h to be served by the central utility plant. These loads will be discussed in even further detail for Technical Assignment 3: Evaluation of Existing Mechanical Systems.

Table 10 – Comparison of Cooling Loads

Air Handling Unit No.	SF / ton		Total Supply Air [cfm/ SF]		Ventilation Outdoor Air [cfm/ SF]	
	Estimated	As Designed	Estimated	As Designed	Estimated	As Designed
AH-1	251.29	242.16	0.92	1.15	0.39	0.46
AH-2	467.47	302.39	0.68	1.06	0.12	0.27
AH-3	99.65	128.16	1.58	1.73	1.50	1.53
AH-4	101.15	124.74	1.50	1.88	1.50	1.50
AH-5	212.46	241.37	1.01	1.16	0.49	0.46
AH-6	160.45	160.67	1.82	2.00	0.50	0.50
AH-7	94.07	96.58	2.01	2.32	1.50	1.93
AH-8	217.66	242.34	0.96	1.07	0.50	0.48
AH-9	217.82	184.67	1.11	1.60	0.50	0.51
AH-10	92.45	100.33	1.98	2.39	1.50	1.77
AH-11	167.19	183.88	2.24	1.91	0.23	0.32
AH-12	229.44	306.35	0.96	1.08	0.45	0.46
AH-13	211.65	237.69	1.06	1.18	0.46	0.47
AH-14	111.38	81.03	3.36	4.27	0.05	0.64
AH-15	225.30	222.27	0.99	1.24	0.50	0.51
AH-16	128.74	130.72	2.93	2.65	0.03	0.40
AH-17	169.54	207.08	1.37	1.25	0.57	0.61
AH-18	646.22	210.78	0.53	0.87	0.08	0.87
AH-19	239.24	225.34	0.98	1.08	0.51	0.54
AH-20	262.85	230.53	1.25	1.30	0.38	0.43
AH-21	193.73	198.27	1.01	1.42	0.57	0.53
AH-22	103.81	132.53	1.50	1.68	1.50	1.54
AH-23	109.10	109.53	1.50	2.06	1.50	1.73
AH-24	218.52	197.61	1.10	1.42	0.50	0.51
AH-25	92.53	88.45	3.61	3.68	0.63	0.92
AH-26	165.42	187.93	1.12	1.22	0.82	0.80
AH-27	95.93	64.69	1.91	2.07	1.50	1.97
AH-28	127.97	122.10	2.94	2.84	0.04	0.43
AH-29	211.23	191.83	1.18	1.47	0.50	0.52
AH-30	222.30	259.50	0.96	1.01	0.44	0.46
AH-31	203.23	250.50	1.06	1.03	0.50	0.52

Air Handling Unit No.	SF / ton		Total Supply Air [cfm/ SF]		Ventilation Outdoor Air [cfm/ SF]	
	Estimated	As Designed	Estimated	As Designed	Estimated	As Designed
AH-32	116.97	111.27	3.22	3.12	0.04	0.47
AH-33	80.46	111.47	2.94	2.10	1.50	1.66
AH-34	198.98	176.29	1.51	1.68	0.50	0.53
AH-35	188.50	193.58	1.14	1.34	0.61	0.63
AH-36	96.25	120.11	1.76	1.86	1.50	1.56
AH-37	308.71	257.46	0.83	1.15	0.30	0.35
AH-38	81.48	106.90	2.73	2.22	1.50	1.64
AH-39	196.12	212.24	0.97	1.09	0.67	0.68
AH-40	379.00	334.12	0.73	0.91	0.22	0.59
AH-41	131.31	131.07	1.67	1.99	0.78	0.86
AH-42	241.28	167.77	0.98	1.64	0.36	0.65
AH-43	157.32	179.74	1.49	1.78	0.56	0.39
AH-44	127.18	119.29	2.46	2.73	0.50	0.60
AH-45	167.34	173.43	1.28	1.49	0.54	0.69
AH-46	143.55	161.09	1.36	1.42	0.84	0.85
AH-47	155.49	155.55	1.51	1.67	0.56	0.74
AH-48	128.87	124.66	2.47	2.57	0.50	0.56
AH-49a	155.79	160.77	1.82	1.87	0.50	0.56
AH-49b	157.17	165.33	1.80	1.82	0.50	0.55
AH-50a	161.21	123.99	1.78	2.39	0.44	0.80
AH-50b	159.98	119.37	1.79	2.48	0.45	0.83
AH-51a	111.77	97.34	1.79	2.33	1.05	1.49
AH-51b	108.76	98.24	1.77	2.07	1.15	1.35
AH-52	172.54	181.84	1.31	1.43	0.55	0.70
AH-53	156.35	126.98	1.81	2.56	0.50	0.64
AH-54	148.31	148.72	1.29	1.64	0.70	0.85
AH-55	129.34	123.84	2.45	2.59	0.50	0.59
AH-56	134.83	149.58	1.42	1.54	0.92	0.92
AH-57	170.53	173.62	1.27	1.49	0.53	0.75
AH-58	159.80	118.84	2.25	2.74	0.50	0.68
AH-59	157.72	156.11	1.23	1.57	0.65	0.90
AH-60	162.63	123.26	1.61	1.99	0.59	1.10
AH-61	332.16	313.50	0.82	1.02	0.19	0.25
CUP AH-1	114.37	105.72	3.08	2.97	0.52	0.52
CUP AH-2	114.37	105.72	3.08	2.97	0.52	0.52
CUP AH-3	170.15	86.16	1.66	2.50	0.36	1.14

Annual Energy Consumption and Operating Cost

Actual annual energy consumption and operating cost data is not available since the terminal is not yet in operation. As a result, TRACE was also used to simulate the annual energy consumption of Terminal 3. Again, this section of the report contains the analysis performed by the mechanical consultant for Terminal 3. It is anticipated that this analysis will be performed again in the new load simulation.

The mechanical design engineer for Terminal 3 has indicated that the load simulation was performed strictly for use in the sizing of mechanical equipment and systems, and was never intended to be used for energy consumption analysis. Therefore, please note that the values contained in this section correlate to a maximum operating profile. In other words, this analysis does not take into account a change in load profiles based on varying occupancy levels and equipment use. These details are likely to be taken into account in the new load simulation.

While this energy analysis does not contain actual load schedules, it does take into account the actual utility rates for the building. These rates are shown in Table 11 – Utility Rates.

Table 11 – Utility rates

Natural Gas (Southwest Gas Schedule SG-5L)			
Period	Service Charge per Month	Consumption Charge per Therm	Demand Charge per kW
All Periods	$150.00	$1.03450	$0.00
Electric (Nevada Power Schedule LGS-3)			
Period	Service Charge per Month	Consumption Charge per kW	Demand Charge per kW
Summer On-Peak	$254.60	$0.10758	$9.17
Summer Mid-Peak		$0.09410	$0.68
Summer Off-Peak		$0.06987	$0.00
All Other Periods		$0.07163	$0.50

The results of the analysis are summarized in Table 12 – Annual Energy Consumption Summary, and Table 13 – Annual Energy Cost Breakdown. Table 12 shows results in a form that also includes the percentage of total energy consumed by various building equipment. The analysis reports do not display the total energy cost of these individual pieces of equipment; however, the cost has been broken down by utility type. Table 13 shows the total yearly annual cost for the electrical and natural gas consumption of the building. This table also shows the annual cost per square foot of building area for the same utility services.

Table 12 – Annual Energy Consumption Summary

Component	Electrical Consumption (kWh)	Gas Consumption (kBtu)	Total Building Energy (kBtu/yr)	% of Total Building Energy
Primary Heating Boilers and Accessories	188,340	14,666,311	15,309,115	3.5%
Primary Cooling Chillers and Accessories	14,050,719	-	47,955,104	10.9%
Cooling Tower Fans and Pumps	6,593,685	-	22,504,246	5.1%
Supply Air Fans	26,498,022	-	90,437,749	20.5%
Auxiliary Pumps	3,770,557	-	12,868,911	2.9%
Lighting	35,212,764	-	120,181,164	27.2%
Electrical Equipment	38,692,356	-	132,057,011	29.9%
Total	**125,006,443**	**14,666,311**	**441,313,300**	**100.0%**

Table 13 – Annual Energy Cost Breakdown

Utility	Annual Cost [$/yr]	Annual Cost per Square Foot [$/(SF*yr)]
Electricity	$11,586,792	$6.18
Natural Gas	$147,350	$0.08
Total	**$11,734,142**	**$6.26**

Once again, it is important to remember that this analysis is greatly simplified, and far overestimated. Even small changes in the occupancy and equipment use schedules can have major impacts on the overall analysis. The results listed in this section should not be considered conclusive until a more accurate analysis can be performed.

References

American Society of Heating Refrigerating and Air Conditioning Engineers, Inc. 2004. ANSI / ASHRAE / IESNA Standard 90.1-2004, *Energy Standard for Buildings Except Low-Rise Residential Buildings*.

JBA Consulting Engineers. 2007. *Construction Drawings for McCarran International Airport – Terminal 3 and Related Projects, Volume 8 of 14, Plumbing.*

JBA Consulting Engineers. 2007. *Construction Drawings for McCarran International Airport – Terminal 3 and Related Projects, Volume 9 of 14, Mechanical*

JBA Consulting Engineers. 2007. *Construction Drawings for McCarran International Airport – Terminal 3 and Related Projects, Volume 10 of 14, Electrical.*

JBA Consulting Engineers. 2007. *100% Design Submission Technical Specifications for McCarran International Airport – Terminal 3 and Related Projects, Volumes 3-4 of 4.*

PGAL, LLC. 2007. *Construction Drawings for McCarran International Airport – Terminal 3 and Related Projects, Volumes 2-5 of 14, Architectural.*

PGAL, LLC. 2007. *100% Design Submission Technical Specifications for McCarran International Airport – Terminal 3 and Related Projects, Volumes 1-2of 4.*

PGAL, LLC; et al. 2007. *Construction Drawings for McCarran International Airport – Terminal 3 and Related Projects, Central Utility Plant.*

United States Green Building Council. 2005. LEED-NC *Green Building Rating System For New Construction & Major Renovations Version 2.2*.

Appendix A – LEED-NC V2.2 Analysis

Figure A1 – LEED-NC V2.2 Checklist

LEED for New Construction v2.2
Registered Project Checklist

Project Name: McCarran International Airport - Terminal 3
Project Address: Las Vegas, NV

Yes	?	No			
1	3	10	**Sustainable Sites**		14 Points
Y			Prereq 1	**Construction Activity Pollution Prevention**	Required
1			Credit 1	**Site Selection**	1
		1	Credit 2	**Development Density & Community Connectivity**	1
		1	Credit 3	**Brownfield Redevelopment**	1
		1	Credit 4.1	**Alternative Transportation**, Public Transportation Access	1
		1	Credit 4.2	**Alternative Transportation**, Bicycle Storage & Changing Rooms	1
		1	Credit 4.3	**Alternative Transportation**, Low-Emitting & Fuel-Efficient Vehicles	1
		1	Credit 4.4	**Alternative Transportation**, Parking Capacity	1
		1	Credit 5.1	**Site Development,** Protect or Restore Habitat	1
		1	Credit 5.2	**Site Development,** Maximize Open Space	1
		1	Credit 6.1	**Stormwater Design,** Quantity Control	1
		1	Credit 6.2	**Stormwater Design,** Quality Control	1
	1		Credit 7.1	**Heat Island Effect,** Non-Roof	1
	1		Credit 7.2	**Heat Island Effect,** Roof	1
	1		Credit 8	**Light Pollution Reduction**	1

Yes	?	No			
1	4		**Water Efficiency**		5 Points
	1		Credit 1.1	**Water Efficient Landscaping**, Reduce by 50%	1
	1		Credit 1.2	**Water Efficient Landscaping**, No Potable Use or No Irrigation	1
1			Credit 2	**Innovative Wastewater Technologies**	1
	1		Credit 3.1	**Water Use Reduction**, 20% Reduction	1
	1		Credit 3.2	**Water Use Reduction**, 30% Reduction	1

1	3	12	**Energy & Atmosphere**		17 Points
Y			Prereq 1	**Fundamental Commissioning of the Building Energy Systems**	Required
Y			Prereq 2	**Minimum Energy Performance**	Required

Y			Prereq 3	**Fundamental Refrigerant Management**	Required

***Note for EAc1**: All LEED for New Construction projects registered after June 26th, 2007 are required to achieve at least two (2) points under EAc1.

	2	8	Credit 1	**Optimize Energy Performance**	1 to 10
				10.5% New Buildings or 3.5% Existing Building Renovations	1
				14% New Buildings or 7% Existing Building Renovations	2
				17.5% New Buildings or 10.5% Existing Building Renovations	3
				21% New Buildings or 14% Existing Building Renovations	4
				24.5% New Buildings or 17.5% Existing Building Renovations	5
				28% New Buildings or 21% Existing Building Renovations	6
				31.5% New Buildings or 24.5% Existing Building Renovations	7
				35% New Buildings or 28% Existing Building Renovations	8
				38.5% New Buildings or 31.5% Existing Building Renovations	9
				42% New Buildings or 35% Existing Building Renovations	10
		3	Credit 2	**On-Site Renewable Energy**	1 to 3
				2.5% Renewable Energy	1
				7.5% Renewable Energy	2
				12.5% Renewable Energy	3
			Credit 3	**Enhanced Commissioning**	1
1			Credit 4	**Enhanced Refrigerant Management**	1
	1		Credit 5	**Measurement & Verification**	1
		1	Credit 6	**Green Power**	1

continued
…

Yes	?	No		
	3	11	**Materials & Resources**	13 Points

Y			Prereq 1	**Storage & Collection of Recyclables**	Required
		1	Credit 1.1	**Building Reuse**, Maintain 75% of Existing Walls, Floors & Roof	1
		1	Credit 1.2	**Building Reuse**, Maintain 100% of Existing Walls, Floors & Roof	1
		1	Credit 1.3	**Building Reuse**, Maintain 50% of Interior Non-Structural Elements	1
	1		Credit 2.1	**Construction Waste Management**, Divert 50% from Disposal	1
		1	Credit 2.2	**Construction Waste Management**, Divert 75% from Disposal	1
		1	Credit 3.1	**Materials Reuse**, 5%	1
		1	Credit 3.2	**Materials Reuse**,10%	1
	1	1	Credit 4.1	**Recycled Content**, 10% (post-consumer + ½ pre-consumer)	1
		1	Credit 4.2	**Recycled Content**, 20% (post-consumer + ½ pre-consumer)	1
	1		Credit 5.1	**Regional Materials**, 10% Extracted, Processed & Manufactured Regionally	1
		1	Credit 5.2	**Regional Materials**, 20% Extracted, Processed & Manufactured Regionally	1
		1	Credit 6	**Rapidly Renewable Materials**	1
		1	Credit 7	**Certified Wood**	1

Yes	?	No		
2	1 0	3	**Indoor Environmental Quality**	15 Points

Y			Prereq 1	**Minimum IAQ Performance**	Required
Y			Prereq 2	**Environmental Tobacco Smoke** (ETS) **Control**	Required
1			Credit 1	**Outdoor Air Delivery Monitoring**	1
	1		Credit 2	**Increased Ventilation**	1
	1		Credit 3.1	**Construction IAQ Management Plan**, During Construction	1
	1		Credit 3.2	**Construction IAQ Management Plan**, Before Occupancy	1
	1		Credit 4.1	**Low-Emitting Materials**, Adhesives & Sealants	1
	1		Credit 4.2	**Low-Emitting Materials**, Paints & Coatings	1
	1		Credit 4.3	**Low-Emitting Materials**, Carpet Systems	1
		1	Credit 4.4	**Low-Emitting Materials**, Composite Wood & Agrifiber Products	1
	1		Credit 5	**Indoor Chemical & Pollutant Source Control**	1
	1		Credit 6.1	**Controllability of Systems**, Lighting	1
		1	Credit 6.2	**Controllability of Systems**, Thermal Comfort	1
1			Credit 7.1	**Thermal Comfort**, Design	1
	1		Credit 7.2	**Thermal Comfort**, Verification	1
	1		Credit 8.1	**Daylight & Views**, Daylight 75% of Spaces	1
		1	Credit 8.2	**Daylight & Views**, Views for 90% of Spaces	1
Yes	?	No			
1	2	2	**Innovation & Design Process**		**5** Points
	1		Credit 1.1	**Innovation in Design**: Provide Specific Title	1
	1		Credit 1.2	**Innovation in Design**: Provide Specific Title	1
		1	Credit 1.3	**Innovation in Design**: Provide Specific Title	1
		1	Credit 1.4	**Innovation in Design**: Provide Specific Title	1
1			Credit 2	**LEED® Accredited Professional**	1
Yes	?	No			
6	25	38	**Project Totals** (pre-certification estimates)		**69** Points

Certified: 26-32 points, **Silver:** 33-38 points, **Gold:** 39-51 points, **Platinum:** 52-69 points

Appendix B – ASHRAE Standard 90.1-2004 Calculations

Table B1 – Summary of Actual Lighting Power Levels

Fixture ID (Tag: Description)	Lamp Wattage [W]	Lamps per Fixture	Fixture Wattage [W]	No. of Fixtures	Total Wattage [W]
A2: 2' x 4' Lensed Grid, 48" T8 Lamp	32	2	64	1,215	77,760
A3: 2' x 4' Lensed Grid, 48" T8 Lamp	32	3	96	2	192
A4: 2' x 4' Lensed Grid, 48" T8 Lamp	32	4	128	5	640
B2: 2' x 4' Lensed Surface, 48" T8 Lamp	32	2	64	179	11,456
B3: 2' x 4' Parabolic Grid, 48" T8 Lamp	32	3	96	1,115	107,040
B3D: 2' x 4' Parabolic Grid, 48" T8 Lamp	32	3	96	14	1,344
B4: 2' x 4' Parabolic Grid, 48" T8 Lamp	32	4	128	37	4,736
C2: 1' x 4' Recessed, 48" T8 Lamp	32	2	64	11	704
C3: 1' x 4' Recessed, 48" T8 Lamp	32	3	96	18	1,728
C4: 1' x 4' Recessed, 48" T8 Lamp	32	4	128	21	2,688
D: 1' x 4' Recessed, 48" T8 Lamp	32	2	64	181	11,584
E: 4' Strip w/ Wireguard, 48" T8 Lamp	32	2	64	6,327	404,928
F: 4' Lensed Wall Mount, 48" T8 Lamp	32	2	64	356	22,784
G1: 8" Downlight, 4 Pin CFL Lamp	35	1	35	10	350
G2: 8" Downlight, 4 Pin CFL Lamp	35	2	70	55	3,850
J: Shower Light, Incadescent Lamp	60	1	60	15	900
K3: 2' x 4' Parabolic Surface, 48" T8 Lamp	32	3	96	24	2,304
L2: 2' x 2' Lensed, 48" T8 Lamp	32	2	64	9	576
M: 6" Downlight, Incandescent Lamp	100	1	100	28	2,800
N: 1' x 4' Wraparound, 48" T8 Lamp	32	2	64	32	2,048
Y4: 1' x 4' Vandal Resistant, 48" T8 Lamp	32	4	128	23	2,944
Z4: 2' x 4' Surface, 48" T8 Lamp	32	4	128	2	256
F1: Small Ceiling Mount, Metal Halide Lamp	150	1	185	541	100,085
F1a: Small Wall Mount, Metal Halide Lamp	150	1	185	32	5,920
F1c: Small Wall Mount, 4 Pin CFL Lamp	42	1	50	40	2,000
F1d: Small Wall Mount, Metal Halide Lamp	70	2	180	144	25,920
F2: 8' Recessed, 48" T8 Lamp	32	2	64	1,223	78,272
F2a: 4' Recessed, 48" T8 Lamp	32	1	32	312	9,984
F3: 8' Recessed, 48" T8 Lamp	32	4	128	190	24,320
F4: 1' x 4' Recessed, 48" T8 Lamp	32	2	64	142	9,088
F5: 8" Downlight, 4 Pin CFL Lamp	42	1	50	2,420	121,000
F5a: 8" Downlight, 4 Pin CFL Lamp	42	2	100	383	38,300
F5b: 8" Downlight, 4 Pin CFL Lamp	42	1	50	44	2,200
F5w: 8" Downlight, 4 Pin CFL Lamp	42	1	50	315	15,750
F10: Downlight, LED Lamp	35	1	35	601	21,035
F12: 16" Surface Cove, LED Lamp	40	1	40	930	37,200
F13: Recessed Accent, Incandescent Lamp	150	1	150	17	2,550
F14: 1' x 4' Recessed, 48" T8 Lamp	32	1	32	601	19,232
F15: 6" Square DL, 4 Pin CFL Lamp	42	1	50	1	50
F17: 4" Recessed DL, Incandescent Lamp	37	1	40	65	2,600

Fixture ID (Tag: Description)	Lamp Wattage [W]	Lamps per Fixture	Fixture Wattage [W]	No. of Fixtures	Total Wattage [W]
F17a: 4" Recessed DL, Incandescent Lamp	37	1	40	151	6,040
F18: Pendant Accent, Incandescent Lamp	37	1	40	4	160
F19: 1' x 4' Pendant DL, 48" T8 Lamp	32	2	64	3	192
F22: 6" Downlight, 4 Pin CFL Lamp	42	1	50	28	1,400
F23: 4' Staggered Strip, 48" T8 Lamp	32	2	64	2,544	162,816
F29: 10" Downlight, 4 Pin CFL Lamp	42	2	100	56	5,600
F31: Compact Strip, 4 Pin CFL Lamp	42	1	50	47	2,350
F32: 4' Strip, 48" T8 Lamp	32	1	32	192	6,144
F33: Steplight, 4 Pin CFL Lamp	13	1	20	22	440
Total	-	-	-	**20,727**	**1,364,260**