9.0 Recommendation

9.1 Air Side System Selection

The original rooftop unit design was compared against several alternatives. After much analysis, an alternative base system could not be found to better meet the criteria set out for the redesign of the LA Fitness, West Oaks location. These systems use less fossil fuel energy, cost less money, and emit less harmful pollutants to the environment.

After processing the results of a long analysis, the design goal for the air system shifted from finding a better alternative, to finding the best configuration possible for the system that is in place. It can be seen that much of the energy being consumed by the building's HVAC system was being used for dehumidification across the coils. The humid outdoor air imposes a high latent load on systems residing in Houston, TX.

Active desiccant dehumidification followed by a sensible heat recovery wheel seemed to be the best way to remedy this problem. The initial idea was to change each of the original packaged rooftop units over to built-up custom units with the new dehumidification technology in place. The hot gas reheat from the direct expansion equipment could be modified to reactivate the desiccant in this scenario as well. However, after reviewing the cost of purchasing 13 modified rooftop units, 13 desiccant wheels, 13 sensible wheels, as well as the cost of having these systems built to the designers specifications on site, it was clear that this was not an economically feasible approach.

The outdoor air for the entire building is responsible for the bulk of the latent load during the year. Knowing this, the next design modification consisted of one large custom built unit that would process all of the outdoor air for the building before it was fed to the packaged units for mixing. This design would severely lower the cooling load on the units' compressors by eliminating a sizable portion of the latent load.

This proposed design also takes advantage of economies of scale. Purchasing and installing 26 separate wheels to process the outdoor air will cost more than purchasing and installing two large units (one desiccant, one sensible) that are centralized.

After redesigning the ventilation air to better meet the requirements of ASHRAE Standard 62.1-2004, it was found that the entire building requires 17,630 cfm. This would serve as the process air stream in the desiccant dehumidification system. Rotor

Source's equipment specifications for their PPS model desiccant wheel showed that their wheel would receive 18,000 cfm of process air, but would also require approximately 6000 cfm for the smaller counterflow air stream that is necessary to reactivate the desiccant surface.

This counterflow air stream can be provided by the one of the original design's exhaust fan (EF-5). This exhaust fan is located relatively close to seven of the units in a fairly central location on the roof. The decision to use this air stream is a result of its excellent location and appropriate amount of airflow at relatively dry conditions. CAD files showing this system's integration are provided in Appendix G.

The custom built unit also requires a heat source that is capable of raising the exhaust stream through the unit to a condition that will remove moisture from the desiccant. The heat source necessary will be a natural gas fired air heater. Natural gas is already being provided to the rooftop to serve the packaged units, so this option is logistically sound.

This configuration was simulated to find its energy consumption for the year. For one year of operation, this system will use 935,067 kWh of energy. This figure takes into account the energy usage by the fan motors, the wheel motors, and the reactivation heat used by the dehumidification unit as well as the energy consumed by the packaged units receiving the pre-treated outdoor air. For a point of comparison, the energy reduction compared to the unaltered original rooftop units is 320,792 kWh (1094 MMBtu). The full comparison can be seen below in Table 9.1.

End-Use	Energy Consumption	Unit of Energy	Cost/Unit	Enery Cost/Year	First Cost of System
HVAC	3190.4	MMBtu	$14.66	$46,771	$563,662
Original Design	4285.0	MMBtu	$14.66	$62,818	$419,000
Differential	-1094.6	MMBtu	NA	($16,047)	$144,662

Table 9.1 – Rooftop Modifications Compared to Original Rooftop Design

This is only system in the course of this study that has potential to meet all three of the design criteria. The system undeniably saves energy. As seen in Table 9.2 below, the suggested system produces less harmful emissions. The only consideration to be made lies in the economic analysis.

Building Emissions lbm/year				
Fuel	**Particulates/yr**	**SO_2/yr**	**NO_x/yr**	**CO_2/yr**
Dehumidified RTU	183	1935	2178	883154
Original RTU	166	1937	2589	1099594
Differential	17	-2	-410	-216440

Table 9.2 Emissions for Proposed Modifications

The rooftop unit scenario with preconditioned outdoor air resulted in a much higher first cost of $563,662. However the units do save $16,047 on energy every year. The payback period for these units was calculated to be 11 years. This payback period is conservative because the calculation assumes that the price of natural gas will only increase at a rate of 3% every year.

Many energy analysts are now predicting that the price of natural gas will be increasing at the rate of 7.5-8% per year. This estimation is not at all unjustified. In fact, the impact of rising natural gas rates became the determining factor in eliminating a combined heat and power system as a design alternative from this site. Using a natural gas escalation rate of 8%, the payback period for this technology is reduced to 8.5 years.

It is assumed that this building will have a 20 year life span. Using either escalation rate for gas, it can be seen that it would be a wise decision to install this dehumidification system at the site as a modification to the original design.

Appendix G includes other useful information about this design including: the CAD layouts of the roof, a schematic of the dehumidification system, psychrometric analysis taken at varying load conditions, and a discussion of the application of this system to other sites.

9.2 Water Side System Selection

Solar water heating is a good fit for LA Fitness. The building requires hot water at a fairly low temperature (120^{0}F). After reviewing solar water heating alternatives it can be seen that using a glazed flat plate collector will prove to be the best choice for this site. Using five of these collectors on the roof will reduce the natural gas consumed by the water heaters an average of 33.94 MMBtu per year. The collectors are an attractive choice for a building owner because the payback period is only 5.3 years. Table 9.3 below provides a comparison of the three types of panels that were modeled for use at the site.

Technology	Model	Energy Delivered Per Year (MMBtu)	% Demand Per Year	First Cost	Payback Period (Years)
Unglazed Flat Plate Collector	Heliodyne Mojave 410	18.94	29.9%	$4,752	8
Glazed Flat Plate Collector	Heliodyne Gobi 408	33.94	53.6%	$5,589	5.3
Evacuated Tube Collector	Thermomax Mazdon 20	43.26	68.3%	$16,999	11.6

Table 9.3 – Solar Energy Collector Comparison

The economic analysis provided did not deduct the cost of any of the original water heaters. There are a few reasons why it was decided to keep all of the existing water heaters in place. The system selected for water heating provides 53.6% of the energy used by the original heaters in a typical year. However, this is not to say that any of the existing water heating equipment could be downsized or removed. If there were to be a cloudy day that would require full hot water demand, solar equipment would not be able to meet 53% of the load. Rather, it is safe to say that 53% of the energy used in a year could be saved if these systems supplement the existing water heating system. The existing water heaters also serve as storage tanks for the hot water delivered by the sun.